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ABSTRACT

Using documentation from a wide range of periods in American history, the student explores the implications for scientific progress of such "typically American" traits as pragmatism, egalitarianism, and commercialism. He is asked throughout to assess the compatibility of science and American culture, government, and business; and to consider whether or not our culture is as conducive to scientific progress as is popularly supposed. The unit culminates in a case study of American attitudes toward the manned lunar program, the single most ambitious scientific and technological enterprise Americans have undertaken to date. (See SO 000 161 for a listing of related documents.) (Author/SBE)

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TEACHER'S MANUAL

SCIENCE AND THE AMERICAN CHARACTER

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SO 000 163

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This unit invites the student to examine the relationship between certain American traits and the progress of science in this country. The student will inquire into the effect on scientists of the American faith in equality. He will consider the implications of the American tendency to emphasize the practical over the theoretical. He will investigate the influence of American businessmen on scientists and inventors. Finally he will participate in a case study of the manned lunar landing program, Project Apollo, a current controversy encompassing and exemplifying the problem as a whole.

Neither a science teacher nor a scientist wrote this unit. Its author is a history teacher, with as much--or, to be precise, as little--scientific training as most history teachers, who wrote it in the hope of filling a gap in the social studies curriculum. It is intended for use with students who may or may not be science-oriented.

Glance through any standard American history textbook. Almost certainly it will treat the role of science and technology as if it were of incidental rather than central importance. Yet more than most countries, the United States has been shaped by scientific and technological progress. This would seem obvious in present-day America, but the crucial ways in which our history has been affected by science are little known to most Americans. This gap in their understanding of our past diminishes their ability to cope with today's world--and tomorrow's.

If we history teachers wish to be believed when we claim to educate young people for citizenship, we might do well to adjust our thinking, and our teaching, to the times through which our students will live. Our America has been a land of science and technology longer than we sometimes think; their America will be so much more advanced that we can scarcely imagine it.

American enterprise in science has functioned within the framework of American culture as a whole. The moral, political and social values which have shaped American expression in the arts and humanities, have inevitably affected the way American scientists have lived, thought, and worked. This unit's success will depend upon the student's involvement in a candid assessment of American cultural values as influences toward, or away from, the enhancement of American life. The student may thereby be stimulated to think his way through to a viable set of ethical standards of his own.

SECTION I

THE INFINITE VARIETY OF THE AMERICAN CHARACTER

The documents in this section depict a set of characteristics which are commonly regarded as "typically American": open-mindedness and love of freedom; admiration for common sense and practical ingenuity; antipathy for abstractions and theorizing; faith in egalitarian democracy; distrust of the exceptional individual; a tendency to place commercial profit above social responsibility, and material success above intellectual achievement. An effective approach might be to challenge the student to identify the characteristics exemplified in each document and to consider just how "typical" they may be.

These selections are intended to spark a preliminary discussion of a broader problem, which will come up again at several points in the unit. The problem is this: what role would a people exhibiting these characteristics be expected to play in the progress of science? Students may be encouraged to attempt some tentative hypotheses, with the understanding that these may change after consideration of the materials that follow.

There are a number of specific possibilities for critical analysis in this section. Some of the documents are based upon unstated assumptions which students should be encouraged to discover. Jefferson's celebrated affirmation (#1) for instance, presents a decidedly optimistic view of civil liberties in our country, especially in view of his own bitter struggles in the time of the Alien and Sedition Acts. Other instances on both sides of this argument might be brought in by students, with discussion aimed at producing a modicum of agreement as to whether the principle of academic freedom has, on balance, been as triumphant in our history as Jefferson asserted in 1820.

An effective use of the selection written by Samuel Miller in 1803 (#2) might be to have the class list the principal criticisms presented and then decide to what extent they remain valid a century and a half later. The perhaps dismaying results might then lead to a discussion of why these American traits have been so persistent.

Simon Newcomb's critique (#3) raises, for the first but very definitely not the last time in this unit, the question of the difference between pure or theoretical or basic science and applied or "practical" science. At this point a committee of students might be assigned the task of bringing in relevant materials, definitions, comments, opinions etc., to serve as a basis for discussion. As we shall see later in the unit, the somewhat academic distinction between pure and applied science has been questioned by a number of authorities. But at this preliminary stage we shall have achieved a good start if we simply make students aware that there are differences of opinion about what might seem like a matter capable of final settlement by mere formulation of a formal definition.

Newcomb's underlying assumption should also be questioned: is it true that theoretical work is always primary, with practical applications and technological progress dependent on it? We will note later that while this has undeniably been true very often, theoretical work has not been an indispensable prelude to all technical advance.

Some interesting assumptions underlie the typically Progressive optimism of W. J. McGee (#4). He repeatedly makes claims for American scientific pre-eminence over Europe in the latter half of the 19th century; students should ascertain how much validity these claims contain. He also speaks of scientific and technological progress without attempting to discriminate between them. Students should be challenged to analyze the ways in which his blurring of the distinction serves to buttress McGee's thesis.

Finally, McGee advances some rather dramatic notions about the ennobling effects of the advance of science upon the American character. Doubtless your students will not wish to let these assertions pass unanalyzed.

Edison's pithy utterances (#5) can stimulate discussion of a charge which every American who ever traveled abroad has surely encountered: that Americans are commercial-minded, money-mad, crass, and mercenary. It is certainly true that Americans have not exactly ignored money, but the question is to what extent has our indisputable interest in financial gain impinged upon our cultural values and our scientific and technological progress? Later in the unit we shall consider materials showing that the commercial mentality has operated both to the detriment and to the benefit of American science. At this point, discussion of the question might focus simply on producing an awareness of the possibility that it might have functioned both ways.

The inherent interest of the Ku Klux Klan statement (#6) might be heightened by having the students read it as if it had been issued not by the Klan but by some other quite respectable political group seeking to win votes. The fact is that it would require relatively few changes to make it an acceptable and still extremely effective speech for almost any political campaign in almost any part of the country today. And if this is so, then surely it says something lastingly true about Americans. It can, of course, be argued that this is not so, that today's Americans are too mature and sophisticated for such low-level appeals. Therein lies a fine possibility for a lively discussion.

Just as the Klan statement is a series of unsupported assumptions, the same may be said of the President's Science Advisory Committee statement which follows (#7). Doubtless the latter is more flattering, the question is how true is it? How do they know, how can they prove, the pleasant things they assert? In comparing these two seemingly antithetical documents, an analysis of their underlying similarity can promote students' ability to judge the reliability and validity of what they read.

The selection of documents in Section I is a merest sampling of available comment on the American character, whether in American sources or foreign. Committees of students could be assigned to compile material from additional sources, perhaps commenting further on the traits mentioned here, perhaps citing other supposedly "American" modes of thought and action. Possible American sources are too numerous to list here, but the better-known foreign ones could include, among many others, Tocqueville, Bryce, Denis Brogan, Harold Laski.

Or, since the selections in Section I introduce the concept that a nation may at different times display contradictory characteristics which would seem to cancel out, research might be divided between those seeking to document the thesis that American attitudes toward culture and science have been predominantly negative, with the opposing side seeking evidence to the contrary.

SECTION II

THE AMBIVALENCE OF DEMOCRACY

The fundamental question posed by the materials in this section may be stated as follows: Is the democratic form of government inherently more favorable to the advance of science than any other? Americans have tended to accept this notion almost on faith ever since the founding of the Republic. As evidence we cite the advantages of our open society, with its guarantees of freedom of thought and inquiry, and its fluid class structure which encourages the emergence of gifted individuals from every social stratum. Considering the matter from the opposite end, some Americans have argued that the practice of science specially fits an individual for active participation and even leadership in a democracy. The alleged intellectual superiority of the scientist has also been cited as entitling him to special recognition within the democratic framework. All of these assumptions have been challenged on a wide variety of grounds.

Part A of this section raises relevant questions within the framework of the Revolutionary and early national periods. How much validity is there in the faith expressed in the first three selections that there exists some special affinity between democracy, culture, and science? The last three selections provide a springboard for discussion of the true relationship between scientific training and the rights and responsibilities of citizenship. They show that science became a hot political issue in the conflict between the Jeffersonians and the Federalists. Documents 4 and 5 illustrate an early use of anti-intellectualism for political purposes. In a sense, scientific mindedness had become equated with intellectualism and had become a political issue. The question is, was it then or is it ever a genuine issue? On the broader question of the role of the intellectual in politics, some fascinating comparisons can be made and some potentially fruitful research projects can be assigned: the John Quincy Adams vs. Andres Jackson campaign of 1824, and the Eisenhower vs. Adlai Stevenson campaigns of 1952 and 1956. It was during the last mentioned that the term "egghead" originated as a pejorative description of Stevenson and his fellow-intellectuals.

Implied throughout Part A is a broader question upon which considerable evidence is presented later: Has America actually been a superior source of scientific advances as compared with other countries, especially those with other forms of government?

Part B focuses on one of the oldest dilemmas of democracy: the status of the uncommon man, the intellectually gifted individual, exemplified in this case by the scientists, in a society dedicated to the rule of the common man. In a sense Jefferson can be placed at the very center of the dilemma, for it was of course he who declared his faith that "all men are created equal" and yet was able to assert with a sincerity no less profound that there was a special role to be played in the new republic by the "natural aristocracy."

Documents 2, 3, and 4 would seem to indicate that 19th-century America did not carry out Jefferson's ideal. These are followed by three 20th-century statements which seemingly cast doubts on our fulfillment of this ideal in more recent times. There will be much to discuss here, but one provocative detail in the statement by the President's Science Advisory Committee may provide a good focus. That is the somewhat mysterious reference to "hard choices." What is being implied here is that responsible officials must ignore the oft-heard demands for "fair" and "equitable" distribution of Federal funds, and base their allocations of science grants solely on the excellence of the institutions and individuals receiving them. It is a fact that the Northeast, the Pacific Coast, and a small area in the Mid-west have received most of these funds, for the simple reason that they have the top scientists and the finest facilities. Congress and the executive branch are under constant pressure from less-favored States and regions for a "fair share" of these funds. The question is whether funds should go to the "natural aristocracy" or be allotted "democratically" regardless of the quality of available facilities or personnel.

These discussions would seem to lead naturally to a broader analysis of the question of whether a democracy should in any way foster a "natural aristocracy." Documents 8, 9, and 10 show that Americans have not always agreed that we should.

Woodrow Wilson's statement is a striking one considering its author. It may be argued that the statement was drawn from a political speech, that Wilson may not have believed what he was saying, and that in a political campaign even an intellectual such as Wilson may be forgiven political utterances. Actually, such considerations are irrelevant, the point being that Wilson did believe that this type of appeal would win votes. He thereby commented on the American character as he understood it.

The last document in Part A, which shows our neglect of gifted youngsters, could serve as the basis for a potentially lively discussion by being related to the students' own experience. If your school practices homegeneous grouping, the merits and defects of stratification based upon intellectual merit can provide the basis for fruitful debate. Able students could be encouraged to contrast the arguments set forth in Plato's Republic for rule by "philosopher-kings" with the tenets of the philosophers of democracy, whether of the 18th-century Enlightenment or of more modern times. Whatever type of discussion you prefer, it may turn out most beneficial if it is aimed not so much at arriving at some definitive resolution of a problem which is probably inherently insoluble, but rather at inculcating an awareness of the subtlety and infinite complexity of the problem.

Part C raises a related but different question: has American democracy in recent years come increasingly close to some sort of subtle domination by "a scientific-technological elite"? The alarm is sounded in the statement, by President Eisenhower (#1). Then, in a group of documents spanning the past twenty years, a series of encounters between scientists and politicians is presented.

The student should be encouraged to form judgments on a number of questions: How did the scientist far in these confrontations? Does the evidence support the expressed fears about a burgeoning scientific elite? Or do the politicians seem firmly in control, perhaps too much so at times? Is the graver danger that of a rampant anti-intellectualism which some observers have seen as characteristically American, and which is dramatized in some of the documents?

Having examined the documents with these queries in mind, the student can then turn to the over-all question of the proper role of the expert, scientific or otherwise, in a democracy. How should our elected representatives deal with these people? How can a layman, and in science almost all politicians like almost all average Americans are laymen, make judgments and decisions about scientific and technical problems? How much absolute reliance should be placed on expert testimony? And what safeguards might be employed to ensure that the testimony is balanced and impartial?

The documents in Part D are intended to bring the student up against a grim reality of the present and make him aware of the need for dispassionate analysis of factors molding this present. We live in a world where our international prestige and national security depend increasingly on our scientific and technological progress. Our communist rivals seem to be more or less matching our pace in these fields, and at times even to be forging ahead in one specialty or another. For example, until very recently the thrust capacity of their rockets was superior to ours. In this situation Americans often tend to comfort themselves with the thought that we enjoy an inherent, guaranteed superiority because ours is an open society under democratic rule. Our scientists, so the argument runs, are freer than those of totalitarian societies and, therefore, will inevitably be more productive. The documents in this section provide some data, and some arguments on both sides of this question. In order to provoke student interest and to challenge some common preconceptions, the preponderance of evidence presented here emphasizes Soviet attitudes and achievements, while comments on American science tend to the skeptical. It will be up to the students to obtain evidence rectifying this deliberate imbalance.

Discussion in this area may prove sterile if it is restricted to recent times. Claims about the supposed direct relationship between political liberty and scientific progress can best be evaluated, in the light of the historical record, as suggested by John T. Edsall (#5). Did the establishment of the world's first major modern democracy in America in fact lead to an unprecedented flowering of science? What is the history of the American achievement or, until quite recently, lack of achievement in science? And what of the status and achievements of scientists under other forms of government? In particular, how are we to account for the successes of communist science?

SECTION III

"PRACTICAL" AMERICANS AND "PURE" SCIENTISTS

The evidence in this section is arranged to involve the student in an examination of one particular American characteristic and its effect on our scientific progress. The trait most commonly viewed as peculiarly American is our practicality, our supposed innate tendency to scorn all abstract theorizing in favor of immediate tangible results to be achieved by cut-and-dry, rule-of-thumb, common-sense, empirical methods.

It is a fact that, despite the fond hopes expressed by our Revolutionary patriots for an unprecedented flowering of science and culture in this first democracy of modern times, the century which followed the Revolution was singularly sparse in American scientific achievement. As the documents in Part A seem to show, this may have been due to an inborn preference for the practical. But is the problem really that simple?

If it is true that 19th-century Americans tended towards the pragmatic over the theoretic, the question is why? Why did men like Franklin and Jefferson emphasize the social utility of science over the pursuit of knowledge for its own sake? Was it really something in the American blood, the American sustenance, the American air? Or were there other factors, stemming not from the psyche but from the economic, political, and social conditions under which the young nation had to struggle and grow? Could a nation as financially weak and economically underdeveloped as America was have reasonably behaved in any other way?

Furthermore, has our subsequent history borne out the thesis that this practicality was an innate and therefore a permanent behavior pattern, or has this practicality turned out to be a temporary mode of action which lasted only as long as the conditions which produced it?

Several fruitful research and writing assignments might be based on these questions. A short paper might take the form of a reply to Tocqueville (#3), perhaps from the point of view of an American of the 1840's, perhaps from that of a present day American. A formal debate could be set up, on the question of whether the pragmatic tendency has continued operating to the detriment of our scientific progress. Half the class could function as a research team digging up data on America's 20th-century achievements in science as evidence that the practical orientation of the 19th was indeed temporary. One obvious field for research in this connection would be the Nobel Prizes; Americans have won a steadily rising share of them, decade by decade, since they were first awarded in 1901. The other half of the class could document the persistence in numerous fields of the anti-theoretical attitude; several portions of this unit can be used as starting points for this research, such as the group of documents immediately following in Part B.

In Part B the student is confronted with the contrasting personalities of a great and greatly idolized American applied scientist-inventor, Thomas A. Edison, and a great but little-known American theoretical scientist, J. Willard Gibbs.

On the surface, Edison seems the archtype of the practical empiricist, with nothing but contempt for "Bulged-headed" theorists. If any students are at all vague about the concrete meaning of the term "applied scientist," the first selection should help to dispel it. Here we see Edison first mastering all the existing scientific knowledge that relates to the specific problem he is trying to solve and then literally applying the knowledge, filtered and reorganized by his own matchless originality and ingenuity; but at no point is he even attempting to create new scientific knowledge.

Students should not be allowed to accept Edison's expressed attitudes toward pure science and scientists at face value. A careful reading of these documents, perhaps enriched by some research into Edison's life and times, will show that he was never really as naive as he loved to pretend, that he was well aware of the role of theory in his work. He may have played little jokes on men like Upton (#3), but the fact remains that he did employ, depend on, and make effective use of pure scientists.

It has even been said that Edison's greatest invention was his laboratory, for the famed Menlo Park establishment was actually the first institution to be staffed by theoretical scientists, applied scientists, engineers, and technicians working as an harmonious team under central direction.

Students should be encouraged not only to detect Edison's ambivalence toward pure science but to analyze it. What motivated a man like Edison to behave as he did and to make the statements he made? Some part of the explanation is undoubtedly to be found in the circumstances of Edison's life, but much of it may be derived from those factors in our history which students have discussed in connection with the preceding subsection. Links may also be sought out with the material discussed earlier in Section II which relates to the interplay between science and democracy, for it has long been popular and "democratic" to jibe at the "eggheads."

The last document in this group (#6) presents Edison's characteristically original ideas about discovery, invention and theory. It deserves detailed analysis. Some commentators have held that Edison was simply confused and had his meanings reversed.

In any case, students can sharpen their own understanding of these terms by testing them against those proposed by Edison. Particularly interesting is his repeated use of the word "theory" to describe his thoroughly pragmatic, almost totally untheoretical methods. Clearly, when Edison says "theory" he means some idea about what will work, not some scientific hypothesis concerning fundamental principles.

J. Willard Gibbs, the subject of the next group of documents (#7-12), may almost be described as the "great unknown" of American history. Most American history textbooks, for instance, make no mention of him whatsoever. If any of your students have ever heard of him it is probably because they are studying physics. It may, therefore, be worthwhile to assign one or more students to do some research and report on this man's life and achievements, for in the annals of world science he ranks as one of the giants. In the course of class room discussion some consideration might well be given to the very fact of Gibbs' obscurity, for that fact itself reveals something characteristic about the American temperament. Name a dozen great American inventors, and most students will have little difficulty identifying them and their achievements; but America's own great figures in pure science, from Gibbs to the Nobel Prize winners of the 20th century, remain unknown to most Americans.

It is with such considerations in mind that the documents relating to Gibbs are presented here. The point is not so much for students to learn what happened to this particular individual, as for them to consider why it happened.

From this discussion, it would seem logical to proceed to consideration of whether conditions have changed since Gibbs' time. Therefore, at this point Waldemar Kaempffert's provocative testimony (#13) is included. No American myth is more cherished than that of the solitary Yankee inventor making his great discoveries by tinkering in a purely "practical" way with homemade gadgets in his quaint private laboratory. This is probably still the popular image even of Edison. The question for students to consider is whether the old myth, here shattered so pitilessly by Kaempffert, had become obsolete only because circumstances had changed drastically by the time of World War II when Kaempffert testified, or whether these same circumstances were actually at work even in the days of Edison and Gibbs? In short, how long has the myth of the purely "practical" inventor, functioning successfully without reference to scientific theory, been a myth? The point is that both Edison and Gibbs would have had exceedingly useful roles to play even in the mid-20th century; each was "modern" though each served a very different function.

Part C brings these discussions to a head by presenting a variety of statements concerning the interplay between pure or basic science and applied science or technology. In some of the documents these are regarded as sharply separate fields of endeavor. "Laws" are even proposed (#1 and 4) which supposedly certify the primacy of basic science, and depict applied science and technology as parasitic and potentially sterile unless carefully restricted to subordinate roles. Other documents cast serious doubt on such rigid distinctions.

These more or less theoretical considerations are followed by a specific instance from recent history (#5) to which they can be applied. President Johnson's statement, launching a major shift in Federal policy on basic research in medicine, poses some relevant issues: How would the type of science policy advocated by Johnson fit into the pattern we have been discussing; i.e., that of the relations between Americans' "practical" prejudices and the ideals of "pure" science? When a President widely regarded as one of our most astute politicians, ceaselessly seeking to govern by consensus, directs Federal scientists to devote greater efforts to attaining "specific results," is it not likely that he is responding to his interpretation of what the American people want? What ultimate effects might this policy shift have on long-range progress in the biological sciences? Before leaping to conclusions, students should be reminded of the previously discussed differences of opinion among scientists as to the inter-relations between basic and applied science.

SECTION IV

"THE BUSINESS OF AMERICA IS BUSINESS"

This section focuses on the ambivalent role played by American business in promoting and hindering science.

America is, after all, the land where capitalism has attained its fullest development. Supporters of free enterprise credit it with our unrivalled material progress and high standard of living. Detractors assert that American capitalists have profited from the nation's fortunate situation more than they have contributed to it. Applying the question to the subject under examination in this unit, it might be stated as follows: have American capitalists behaved as ruthless exploiters or enlightened patrons towards our scientists and inventors?

As the documents indicate, our history supports both theses.

American businessmen have sometimes dealt with science only as a potential source of immediate profit, blindly ignoring both the longer-range possibilities and the public interest. As the William Whyte study (#9) shows, there still exist business organizations, including some of the biggest, which continue to behave in that manner today. On the other hand, there exists substantial evidence attesting to the most enlightened patronage of science by business from Edison's time to the present.

For example, in considering the contrast between Western Union's almost incredible dismissal of Alexander Graham Bell and his "electrical toy" (#3) and GE's long support of Langmuir in the study of any problem that interested him (#7), students should ponder well the social role of the profit motive. It can be and it has been reactionary, as when Edison describes the telephone company's suppression of technical improvements (#4), but it also can be and has been a progressive force, as when GE invests part of its profits in uncommitted research and then later "draws a circle" around what has been discovered (#8).

Students might be directed to consider certain broad questions in the light of the conflicting evidence presented here. Would American scientists and inventors really have been "freer," as some of them, such as Edison, apparently felt at times, if they had not had to depend on capitalist support? Would they have been as productive? It is, after all, not the role of the creative person to turn his creation into cash, but he does need and even enjoy receiving cash for it. In our society it has been the capitalist who has provided the cash incentives. There are also social and economic requirements for successful innovation; the creator cannot and does not work without reference to the needs and capacities of his society. For instance, when Edison invented the electric light, his problem was still far from solved, for he still had to devise a feasible system for feeding electric power to numberless users of the new device. The fifth selection shows that he obtained capitalist support for this tremendous and technically dubious venture which, indeed, would have been impossible to implement without the abundant financial resources of a J. P. Morgan.

A short paper dealing with the problems raised in this section might consist of an attempt to strike a balance between the positive and negative effects of the business mentality upon American science and technology. Students might either base their work on the documents made available here or might be required to enrich this material with additional research data. The rise of big business is one of the most exhaustively studied aspects of all our history, and students should, therefore, experience little difficulty in finding sources relating to this subject.

SECTION V

CASE STUDY: PROJECT APOLLO

No peacetime enterprise undertaken by the Federal government has ever captured the popular imagination as has the space program. Yet this glamorous endeavor raises a whole range of troublesome questions. Well-directed discussion of these issues will involve the student in an inquiry which can fulfill the fundamental objectives of the unit. Requiring the student to examine some highly controversial evidence relating to a well publicized "scientific" venture may stimulate him to reconsider some notions about science, technology and the American temperament which most Americans take for granted. The materials discussed in previous sections of the unit can be employed as analytical tools in this final inquiry.

Before proceeding to specific suggestions, it may be helpful to list some of the broader questions raised by the decision to achieve a manned landing on the moon by 1970, which is the essence of Project Apollo: How "scientific" is it? How "democratic" is it? What does it indicate about the maturity and judgment of the American people? Have Americans understood the true nature and wise use of science and technology? Considering the costs, and the effects on other branches of scientific investigation, is beating the Russians to the moon a valid national goal? Finally, what does Apollo reflect of the overall status of American culture?

The set of statistics comprising the first document should not be bypassed without considering some significant implications. As a starter, it should not take long for students to figure out what proportion of the total Federal budget (currently running at approximately $105 to $110 billion) is represented by the total devoted to "R & D" (research and development, the government's term for pure and applied science). This proportion of approximately one-sixth is staggering. As the document indicates as recently as just before our entry into World War II we were spending a relatively tiny $74 million for science. Can this single fact be taken as an answer to those who charge that Americans do not support science adequately? What seems to be the obvious answer is, as usual, misleading, and further analysis will be necessary.

One piece of evidence would seem to be at hand in the statistics showing a rise in the proportion of the total devoted to basic research. Seemingly, this would appear to constitute prima facie evidence that we now understand the importance of pure science, but the question is, basic research about what? Part of the answer lies a few lines further down: nearly half of the total goes for defense purposes and must therefore be ascribed to undoubtedly essential but nonetheless destructive purposes.

Science for war we unfortunately must have, but whether we may legitimately class this with science per se, is a question well worth some discussion--time.

Another one-third of the R & D total, as shown in the first selection, goes to NASA for the space program. We shall be examining this allocation in detail throughout this section. Hence no detailed comment seems advisable at this point.

Almost one-tenth of the total science expenditure goes to atomic energy. What proportion goes to applied or technological work? What per cent may be related to defense? These and other aspects of the precise nature of this expenditure might well constitute a research problem for an interested student, though only indirectly related to the specific problem before the class.

But the key fact to be noted and discussed here is that only 10 per cent of the government's entire science allocation is assigned to research outside the three fields of defense, space, and atomic energy. The class might attempt a list of other scientific-technological problems facing the nation to which Federal funds might constructively be devoted. It would certainly not be difficult to ascertain just what these remaining funds are actually being spent on. The question then demanding consideration is whether the existing balance makes good sense.

Moving on to document 2, the most interesting feature is the way in which it translates the vast sums involved in the moon program into humanly understandable terms. Surely the alternative activities proposed here are all highly desirable. Students should not be permitted to accept the underlying premise of this oft-used gambit at face value, however. The fact that the money could be used for these constructive purposes here on earth were we not spending it to send men into space by no means proves that it would be used for such purposes as an alternative to the space program. There are certain built-in "persuaders" in the space program that have thus far convinced Congress that the costs involved are worth while, the most influential of these is being the Soviet Union's rival effort in space. But the other, perhaps more admirable ways we might spend the money have no such motivations. It is a fact that the economy benefits from the expenditures on space. It can be argued that were we not spending the money to get to the moon we might not be spending it at all and that the economy would simply suffer to the extent of a $20-to-$30 billion loss. There are, of course counter-arguments to consider: some Americans feel that the Federal government simply should not be spending as much of the people's money it does, regardless of what it is being spent for.

The results of the American association for the Advancement of Science poll (#3) provide another opportunity for students to test their ability to interpret statistical data.

Some of the results which students might be encouraged to discover and analyze include the following: The scientists generally did support the objective of a manned lunar landing; only 7% opposed it, but many expressed reservations about the priority of the program, its costs and its potential benefits. Only 31% favored a high priority for landing a man on the moon by 1970, Apollo's stated goal. Only about one-fifth considered the 1970 deadline a reasonable objective. The vast majority felt that current expenditures for the space program are too high. Over 60% felt that space should receive one-fifth or less of the total science expenditure. It seems especially significant that, although they naturally favored scientific studies as the most important justification for manned exploration of the moon, the scientists gave lunar exploration a low rating for "potentiality for producing important new knowledge." Finally, there are some intriguing possibilities for discussion in the rather unconventional grounds for approval of the space program suggested by the ex-president of the American Chemical Society and in the contrasting, decidedly critical attitude of the Harvard astronomer (#4 and 5).

It should be obvious, too, that there does exist a body of scientists who do favor the moon program and who presumably have been consulted about it, many of whom are doubtless helping to conduct it. If there exists such substantial disagreement among the scientists, how then shall laymen form intelligent judgments on this or other scientific matters? Moreover, were the questions posed in the AAAS poll the only really relevant ones, or are there other, non-scientific considerations in favor of the space program that may be equally compelling?

Probably the most thorough critical analysis Project Apollo has received at the hands of an outsider is contained in Amitai Etzioni's book The Moon-Doggle, the title of course being a pun on the term "boondoggle," formerly used by critics of the New Deal as an unflattering description of its supposedly wasteful and unproductive public works programs. Only a few highlights of Etzioni's none-too-gentle attack are presented here; a reading of his entire book and report to the class by a group of students might provide useful additional grounds for discussion.

One effective way to use the Etzioni material might be to require your students to attempt answers to his arguments, even before they have read the answers put forward by NASA officials and others as presented later in this section. For example, is it true that "Nobody is setting national policy in these literally vital matters"? There exist thousands of pages of the most painstaking Congressional hearings on these problems and there is the relevant work of the President's Science Adviser and Science Advisory Committee. It is obvious that some thought has gone into these decisions. The fact that the policy may be questionable does not necessarily prove that there is no policy, but perhaps only that Etzioni does not like the policy.

One particular element of Etzioni's presentation is worth special attention: his charge that many pro-Apollo scientists "base their opinions on non-scientific considerations." In the brief statement by the ex-head of the American Chemical Society (#4) and in the more extended statement by Harold Urey (#7) we have relevant evidence. Here we confront a fundamental issue: what are the rights and privileges of scientists in dealing with issues that transcend the purely scientific? How much weight should be given to their opinions when they step outside their own fields to express their views about the values of "adventure," or about political questions such as the likelihood of Federal funds being devoted to other purposes if not to space, etc.? Are scientists any more qualified than laymen on such matters? On the other hand, if we are to submit what scientists say to such rigorous analysis, we then have the right also to question a sociologist's ventures into theorizing about the effects of the space race "on the human spirit." Can Etzioni's admittedly eloquent charges be factually documented?

You may prefer to use the Etzioni document as the basis for a direct confrontation with NASA's pro-Apollo arguments (#9 and 10). Students might attempt a written comparative analysis, or a livelier approach might take the form of a debate.

The Kennedy statement (#8) will probably serve our purposes best if it is discussed in two connections. First, we have here a fine example of the intersection of the scientific and the political. No meaningful conclusions about the Apollo problem are possible without consideration of its political and especially its international implications. The discovery which should be pressed home in this connection is one we have encountered before in this unit--the seemingly obvious but too often overlooked fact that the two disparate fields of science and politics have become so inextricably intertwined in our time that few decisions in one can be taken without impinging upon the other.

Secondly, we shall see a reference to and a discussion of the Kennedy statement in the course of the Congressional interrogation of NASA chief James Webb (#9). Webb places all blame on the Russians for the lack of fulfillment of Kennedy's hopes. Students should consider whether we may not bear a share of the blame, a possibility which Webb ignores. It is, after all, a fact that scientific cooperation with the Russians has been found to be quite feasible and beneficial to both sides in a number of other fields: the International Geophysical Year, the "Year of the Quiet Sun," and Antarctic studies, to mention the best known. Students might research and report on some of these. That the Russians are often intransigent and uncooperative is unquestioned, but how hard have Americans tried to break down the Russians' hostility? And how hard should we try, if at all? The sarcasm of Webb's tone may be taken as one element in discussion of this aspect of the problem.

Webb's entire statement (#9) is worth careful study. Primary emphasis is placed on what Webb sees as the urgency of preventing the Russians "from forging ahead as the unchallenged leader in space." Once again we are confronted by the complex problem of political motivations for scientific-technological activities. Just as we have previously questioned the import of scientists' opinions in political matters, we may now discuss the reliability of politicians' judgments in scientific areas. Since there apparently exists substantial evidence that the scientists themselves are dubious about the scientific value of the program, whose judgment should prevail? Theoretically, in a democracy, the decisions can and should be safely left to the people's elected representatives. Since Congress has in the past voted to support the space program, the decision would seem to be a "democratic" one. But shall our democracy ignore the qualified opinions of its "natural aristocracy," scientists in this case?

Relevant to these considerations are Webb's fascinating comments about public opinion. He flatly declares it to be "less valid than the kind of analysis that we /NASA/ give you." Apparently for Mr. Webb, at least, there would seem to be natural aristocracy whose opinions deserve privileged consideration.

Students should also examine closely that portion of Webb's remarks wherein he makes predictions about the "public reaction" that would ensue if it were believed that the Russians were getting ahead. Webb passes lightly over the public-opinion poll about which Congressman Mosher was questioning him in favor of his own apparently unsupported beliefs about public opinion. This is an example of an effective and frequently employed technique of argument. Students should note the similarity of the technique used in the following paragraph by Congressman Davis, with its undocumented--and undocumentable--assumptions about "every right-thinking American citizen."

Robert Seamans' testimony (#10) provides an interesting comparison with the scientists' criticisms discussed earlier. Here students should consider whether or not Seamans actually answered the objections that have been raised? He declared himself about to discuss "the role of man in scientific investigation in space," but did he do so, or did he simply state NASA's plans very summarily and then conclude that the problem was not really scientific anyway but "technological," "operational," and "socio-political"? To what extent may this be a quite accurate judgment?

All of these considerations culminate in the Times editorial which ends the unit. Many of the points raised previously in the unit can be applied to this document. For example, it once again raises the question as whether Apollo's funds could be used "to meet urgent human needs" in other areas, a proposal which is vulnerable to the same doubts we noted earlier. One other extremely interesting line of investigation and discussion is suggested in the editorial: the extent to which the 1961 decision to invest in space may have been motivated by political factors current at that time which are perhaps no longer relevant. There are some cogent passages in the Etzioni book, not included here, which bear directly on this question. Discussion of the editorial might conclude with a consideration of the nature of the policy shift it forecasts. Students might draw up their own proposals for a desirable program for space exploration.

You will doubtless think of numerous possibilities for a general written assignment to deal with the fundamental questions raised by the unit. One occurring to the author, which you may find helpful:

THE AMERICAN SCIENTIST: NATURAL OFFSPRING OR

OUTCAST OF OUR DEMOCRATIC TRADITION?

ED041802

EXPERIMENTAL MATERIAL
SUBJECT TO REVISION
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STUDENT'S MANUAL

SCIENCE AND THE AMERICAN CHARACTER

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INTRODUCTION

Every time Americans move a step closer to landing on the moon, or conquering another disease, or producing a computer more efficient than the human brain, or mastering the chemistry of life itself, we assure ourselves that America leads the world in science. We may even list reasons why this is inevitable. It is because our free, open society permits any man to inquire into any problem. It is because our democracy encourages the superior intellect to rise out of any social class. It is the way Americans are: curious, venturesome, tolerant, ingenious, ceaselessly seeking to do things better, faster, more easily, more productively. And all of this may well be true.

But it may not be the full truth.

The rise of science in America is the story of a love affair between the American people and the future; but like all love affairs, it is full of misunderstandings and complications as well as joys and triumphs. This unit invites you to investigate that affair in the hope that you will be better equipped to help guide America toward her fast-moving future.

SECTION I

THE INFINITE VARIETY OF THE AMERICAN CHARACTER

In the spring of 1962, President John F. Kennedy invited all living winners of the Nobel Prize to a dinner in their honor at the White House. It was the first such tribute to scientific and literary achievement in our history. During the evening the President remarked with evident satisfaction that there were more brains in the White House at that moment than at any time since Thomas Jefferson dined there alone.

Nearly twenty years earlier General Leslie R. Groves, head of the World War II atomic bomb project, greeted the newly arrived scientists at Los Alamos with a jibe which probably reflected the average American's opinion of scientific theoreticians: "At great expense, we have gathered here the greatest collection of crackpots ever seen."

Between these two extremes lies the extraordinary diversity of American response to cultural developments in general and to scientific ones in particular. The documents in this section present a sampling of opinions drawn from a wide variety of sources and several stages of our history. They may serve as a basis for some tentative conclusions of your own regarding the relationships between American characteristics, American culture and American science.

1. One of the three achievements for which Thomas Jefferson wished to be remembered was the founding of the University of Virginia. In a letter dated December 27, 1830, to William Roscoe, an English historian,

Jefferson in commenting on the University expressed a cultural ideal Americans have often proclaimed:[1]

> [The University is to allow unfettered research in any area; the author claims that any errors temporarily supported will be dispelled by further unhampered investigation.]

2. Possibly the most astonishing fact about the selection which follows is that it was published in 1803. The author was a Presbyterian minister in New York; interestingly, he was also a member of the American Philosophical Society, then the nation's leading scientific body.[2]

> It must, however, after all, be acknowledged, that what is called a liberal education in the United States, is, in in common, less accurate and complete; the eruditation of our native citizens, with some exceptions, less extensive and profound; and the works published by American Authors, in general, less learned, instructive, and elegant, than are found in Great-Britain, and some of the more enlightened nations on the Eastern continent. These facts, it is apprehended, arise not from any deficiency of talents in our country, nor from any inaptitude in its soil or atmosphere to promote the growth of genius; but from one to another, and, in some cases, from a combination of the following causes.
>
> 1. Defective plans and means of instruction in our Seminaries of learning. The great majority of our Colleges have very inadequate funds. . . . In some instances, also, the Trustees or Governors of American Colleges, either from their own ignorance, or in compliance with popular prejudice, have so contracted the time requisite for completing a course of instruction, as to render it necessary wholly to dispense with, or lightly to hurry over, some of the most important branches of knowledge. Accordingly, in some of these institutions, Mathematical Science is unpopular, and the acquisition of as little as possible especially of the higher branches of it, enjoined on the student. . . .

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[1] Quoted in Adrienne Koch and William Peden, eds., The Life and Selected Writings of Thomas Jefferson (The Modern Library, New York, 1944; Random House, Inc.) 702.

[2] Samuel Miller, A Brief Retrospect of the Eighteenth Century in Two Volumes: Containing a Sketch of the Revolutions and Improvements in Science, Arts, and Literature During That Period (T. & J. Swords, New York, 1830), II, 404-407. [Footnotes omitted.]

2. *Want of Leisure*. The comparatively equal distribution of property in America, while it produces the most benign political and moral effects, is by no means friendly to great acquisitions in literature and science. In such a state of Society, there can be few persons of leisure. It is necessary that almost all should be engaged in some active pursuit. Accordingly, in the United States, the greater number of those who pass through a course of what is called liberal education, in the hurried manner which has been mentioned, engage, immediately after leaving College, in the study or business to which they propose to devote themselves. Having run over the preliminary steps of instruction in this business, probably in a manner no less hurried and superficial than their academic studies, they instantly commence its practical pursuit; and are, perhaps, during the remainder of life, consigned to a daily toil for support, which precludes them from reading, and especially from gaining much knowledge out of their particular profession. Such is the career of ninety-nine out of an hundred of those in our country who belong to the learned professions. When the alternative either lies, or is supposed to lie between erudition andpoverty, or confortable affluence and moderate learning, it is not difficult to conjecture which side will be chosen; nor is it surprizing that, in such a state of things, there should be less profound erudition, . . .

3. *Want of encouragement to learning*. Men cannot be expected to labour without the hope of some adequate reward. Genius must be nourished by patronage, as well as strengthened by culture. . . . Hence, in those countries where genius and learning are best rewarded, there they are ever found to be most cultivated. In the United States, the rewards . . . are small and uncertain. . . . There are no rich *Fellowships* in our Universities to excite the ambition of students; no large ecclesiastical benefices to animate the exertions of literary divines. Academic chairs are usually connected with such small salaries, that they present little temptation to the scholar; and, finally, the State offers very inconsiderable motives for the acquisition of knowledge, and the exertion of talents. Its rewards are small, and its favour capricious. Can it be wondered, then, that those who have some acquaintance with books, and hold important stations, are more anxious to secure pecuniary advantages, and to place themselves in a situation independent of popular favour, than to . . . do honor to their country by the display of intellectual preeminence?

Besides, the spirit of our people is *commercial*. It It has been said, and perhaps with some justice, that the *love of gain* peculiarly characterizes the inhabitants of the United States. . . . In such a state of Society, men will not only be apt to bend their whole attention to the acquirement of property, and neglect the cultivation of their minds as an

> affair of secondary moment; but letters and science will seldom be found in high estimation; the amount of wealth will be the principal test of influence; the learned will experience but little reward either of honour or emolument; and, of course, superficial education will be the prevailing character.

3. The year 1876, centennial of American independence, produced innumerable patriotic utterances and some critical analyses of American achievements. The nation's foremost astronomer, Simon Newcomb, contributed an essay surveying the state of American science:[3]

> If we were called upon to decide in what field of purely intellectual effort a people, situated as ours were at the beginning of their national existence, would be least likely to distinguish themselves, we should hardly hesitate to say, the field of abstract science in all its parts, physical, political, and intellectual. . . . One reason for this conclusion lies upon the surface.
>
> If, now, one enters upon a critical examination of the judging faculty of the American people, as shown by their reasoning on subjects of every class, one can hardly avoid being struck by a certain one-sidedness in its development, having an important bearing on its fitness for scientific investigation. Within a certain domain, usually characterized as that of practical sagacity and good sense, they have nothing to be ashamed of. Where the conclusion is reached by a process so instinctive that it is not reduced to a logical form, and where there is no need of an analysis of first principles, we may not unfairly claim to be a nation of good reasoners. But, if we pursue any subject of investigation into a region where a higher or more exact form of reasoning is necessary, -- where first principles have to be analyzed, and a concatenation of results have to be kept in the mind, -- it must be admitted that we do not make a creditable showing. It might be admitted that we do not make a creditable showing. It might almost seem as if the dialectic faculty among us had decayed from want of use. The plain "common-sense" of the fairly intelligent citizen has in most cases so completely sufficed for all the purposes where judging

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[3] Simon Newcomb, "Abstract Science in America, 1776-1876," North American Review (January, 1876), 88, 91-92.

> capacity was required, that the need of more exact methods of thought has never been felt by the nation at large. . . .
>
> No two sets of ideas are more completely antagonistic than those which animate the so-called "practical man" of our country, and those which animate the investigator in any field which deserves the name of science or philosophy. The facts that, in its methods and results, nothing is really more practical, in the best sense of the word, than modern science, and that it is to the discovery of natural laws by men of science that all the benefits which the practical man most highly values are due, do not in any way lessen this antagonism of fundamental ideas. The first condition of really successful and important scientific investigation is, that men shall be found willing to devote much labour and careful thought to that subject from pure love of it, without having in view any practical benefit to be derived from it as an important consideration. . . . If the practical man should object to useless knowledge as dross, we should reply, that he cannot have the gold without the dross; that such a thing as a discoverer of useful natural laws and an ignorer of useless ones is unknown in the world's history, and will probably remain so. In fact, so far as the discovery of new laws is concerned, it is impossible to say whether a discovery will or will not be useful until after it is made, -- perhaps generations afterward; therefore he who waits to see the utility before seeking for the discovery will never discover at all.

4. The author of the following statement, W. J. McGee, was one of America's first anthropologists and a close associate of Theodore Roosevelt. His survey of American scientific achievement, written a generation after Newcomb's, is based on a very different set of assumptions about the nature and effects of scientific progress, assumptions probably still shared today by many Americans.[4]

> The progress of the nation during the half-century is beyond parallel. . . . The subjugation of natural forces has proceeded at a higher rate, and the extension of knowledge and the diffusion of intelligence has gone forward more rapidly still. This advance, so great as to be grasped by

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[4] W. J. McGee, "Fifty Years of American Science," Atlantic Monthly, LXXXII (1898), 307-320.

few minds, is the marvel of human history. The world has moved forward as it never did before. Yet fully half of the progress of the world during the last fifty years, has been wrought through the unprecedented energy of American enterprise and genius, guided by American science. . . .

The characteristic of American inventiveness is its diffusion. Invention is as free as the franchise, and open competition gives life to genius no less than to trade. American devices . . . are so diffused that every citizen is in contact with the products of physical science and mechanical skill: everybody may have a machine-made watch better than the average hand-made product of Geneva, nearly equal to the tested Swiss chronometer; every family may have its sewing-machine and telephone; and every man, woman and child wears machine-made buttons, pins, hats and textile fabrics. . . .

With the advance of the half-century in simply applied mechanics, there have been still greater advances in the knowledge of the more obscure powers of nature, manifested in electricity and magnetism, in sun and wind and storm, even in vitality and mental action. Some of these have been made in Europe, but more in America. Fifty years ago Morse and Henry were doing the final work required to transform the electric telegraph from a physical experiment to a commercial agency . . . then came Edison with an eruption of brilliant inventions; and today time and space are as if they were not, and from sea to sea our subjects of thought are as one. . . .

In truth, America has become a nation of science. There is no industry, from agriculture to architecture, that is not shaped by research and its results; there is not one of our fifteen millions of families that does not enjoy the benefits of scientific advancement; there is no law in our statutes, no motive in our conduct, that has not been made juster by the straightforward and unselfish habit of thought fostered by scientific methods. A nation of free minds will not be selfish or cruel; and the sense of uniformity in nature finds expression in national character, -- in commercial honesty, in personal probity, in unparalleled patriotism, as well as in the unequalled workmanship which is the simplest expression of straight thinking . . . ; but greatest of all in present potency and future promise is the elevation of moral character attained by that sense of right thinking which flows only from consciously assimilated experience, -- and this is the essence of science now diffused among our people.

5. No American scientist or inventor has ever stood higher in public

esteem than Thomas A. Edison. His frequent, candid self-revelations, such as those below, never diminished his popularity.[5]

> [Edison calls himself an inventor, not a scientist, by virtue of his profit motive, an interest he acquired following some hard, practical experience.]

6. The Ku Klux Klan has always claimed to embody true American ideals. Though most Americans have rejected the Klan's extremism in racial and political matters, the following statement by a Klan leader of the 1920's may express something profound and persistent in American culture:[6]

> [In the statement the Klan describes itself: Its members are loyal Americans, "plain people" who believe in the reliability of emotional and intuitive judgments over the "fine-haired reasoning of the denatured intellectuals."]

7. The following estimate of the American people was written in 1960 by the President's Science Advisory Committee:[7]

> Both the security and the general welfare of the American people urgently require continued, rapid, and sustained growth in the strength of American science. . . . We believe that most Americans are in favor of more and better science. In a general way Americans recognize that scientific understanding is at once highly valuable in its own right and quite indispensable for the sustained progress of a modern industrialized society. We are proud of our great accomplishments, and we become concerned whenever it appears that our scientific effort in any field may be second-best. Most of all we have learned to recognize that the defense and advancement of freedom require excellence in science and in technology.

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[5] Matthew Josephson, Edison, A Biography (McGraw-Hill Book Co., New York, 1959), 283, 403.

[6] Hiram W. Evans, "The Klan's Fight for Americanism," North American Review, CCXXIII (March-April-May, 1926), 38ff; in Richard Hofstadter, Anti-Intellectualism in American Life (Alfred A. Knopf, New York, 1963), 124-125.

[7] President's Science Advisory Committee, Scientific Progress, The Universities and the Federal Government (Government Printing Office, Washington, 1960), 1-2.

SECTION II

THE AMBIVALENCE OF DEMOCRACY

It is a commonplace of American belief that our democratic way of life ensures American supremacy in science. Actually, the relationship between science and democracy has been multifaceted. Being democratic has often helped move our science forward; but sometimes, in perhaps unexpected ways, it may have held our scientists back.

A. Revolutionary Faith and Federalist Fury

The spokesmen of the American Revolution were understandably anxious to vindicate the radical step they were taking. Some composed glistening prophecies for the future of the new democracy. But before long certain of their aspirations came under attack.

1. In Charleston, South Carolina, on the second anniversary of the Declaration of Independence Dr. David Ramsay delivered "An Oration on the Advantages of American Independence":[1]

> [Dr Ramsay sees the development of arts and sciences as inevitable in light of our history, independence, and natural resources. He hopes for cultivation of the arts of peace and "useful knowledge" and foresees the growth of arts and science which will "illuminate . . . the most distant retreats of ignorance and barbarity."]

2. The stanza which follows is from a long patriotic poem entitled "The Rising Glory of America," written by Philip Freneau and Hugh H.

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[1] Quoted in Brooke Hindle, The Pursuit of Science in Revolutionary America (University of North Carolina Press, Chapel Hill, 1956), 250-251.

Breckenridge shortly after the Revolution:[2]

> [The selection expresses a belief in liberty as a necessary prerogative for the advancement of science.]

3. In his First Annual Address to Congress George Washington expressed an attitude shared by many Revolutionary leaders:[3]

> [T]here is nothing which can better deserve your patronage than the promotion of Science. . . . Knowledge is in every country the surest basis of public happiness. In one in which the measures of Government receive their impression so immediately from the sense of the Community as in ours it is proportionably [sic] essential.

4. Despite the advocacy of science and scientific thinking by many Federalists, it was Thomas Jefferson who was most clearly identified with the rationalism and pro-scientific thinking of the 18th century Enlightenment. His beliefs made him the target of personal political attacks such as the following, levelled by the Reverend Clement C. Moore:[4]

> [Moore criticizes scientists for their vanity, presumption, and misapplication of energy; he laments their influence on the country.]

5. In a pamphlet entitled "The Claims of Thomas Jefferson to the Presidency, Examined at the Bar of Christianity," Asbury Dickens, another Federalist partisan, wrote as follows:[5]

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[2] Fred L. Partee, ed., The Poems of Philip Freneau in Brooke Hindle, The Pursuit of Science, 249.

[3] John C. Fitzpatrick, ed., The Writings of George Washington, 30 (Government Printing Office, Washington, 1939), 493.

[4] Quoted in G. Adolph Koch, Republican Religion: The American Revolution and the Cult of Reason (Henry Holt and Co., New York, 1944), 274.

[5] Quoted in Edwin T. Martin, Thomas Jefferson: Scientist (Henry Schuman, Inc., New York, 1952), 221.

> [Dickens claims that the fields of science and government are mutually exclusive and points to Newton's training as the worst possible for a ruler of men.]

6. In 1799, Jefferson expressed his beliefs in a letter to a young student.[6]

> I join you . . . in branding as cowardly the idea that the human mind is incapable of further advances. This is precisely the doctrine which the present despots of the earth are inculcating, and their friends here re-echoing . . . "that it is not probable that anything better will be discovered than was known to our fathers." We are to look backwards then and not forwards for the improvement of science. . . . But thank heaven the American mind is already too much opened, to listen to these impostures, and while the art of printing is left to us, science can never be retrograde; what is once acquired of real knowledge can never be lost. To preserve the freedom of the human mind then and freedom of the press, every spirit should be ready to devote itself to martyrdom; for as long as we may think as we will, and speak as we think the condition of man will proceed in improvement. The generation which is going off the stage has deserved well of mankind for the struggles it has made. . . . If there seems to be danger that the ground they have gained will be lost again, that danger comes from the generation your contemporary [sic]. But that the enthusiasm which characterizes youth should lift its parricide hands against freedom and science would be such a monstrous phaenomenon [sic] as I can not place among possible things in this age and this country.

B. Democratic Equality and Innate Inequality

Two principles have exerted opposite pulls on the American mind since the founding of the Republic. Both can be read into the meaning of democracy. Yet each seems to negate the other.

1. The man who unforgettably stated that "all men are created equal" also held other, seemingly contradictory views:[7]

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[6] Quoted in Adrienne Koch, Jefferson and Madison: The Great Collaboration (Alfred A. Knopf, New York, 1950), 181-182.

[7] Thomas Jefferson to John Adams, Oct. 28, 1813 in Adrienne Koch and William Peden, eds., Writings of Thomas Jefferson, 631-632.

> [Jefferson describes two aristocracies, one based on wealth and the other on abilities. He encourages the recognition and use of the latter group for the preservation and improvement of the institutions of our government.]

2. Famous primarily for his novels, James Fenimore Cooper was also an active participant in the politics of the Jacksonian era. In 1838 he published a volume of essays on the nature and workings of American democracy in which he made the following comment:[8]

> [Cooper observes that although a democracy tends toward mediocrity in all things, perhaps in the future a larger group of well-educated, discerning people might arise from the masses and improve the general taste and knowledge. Despite his criticism of the "masses," he expresses confidence in the collective wisdom of the group especially in political matters.]

3. Joseph Henry and Alexander Dallas Bache rank high among the few major scientists American produced during the 19th century. Henry made significant contributions in electro-magnetic theory; Bache was a geophysicist and administrator. Here Henry, recently returned from abroad, shared with Bache his reaction to the condition of science in America and his estimate of the popular mentality, as he found it upon his return:[9]

> [The writer laments the prevalence of "charlatanism" and scientific "quackery" in the U.S. He cites some examples of such behavior and even a case of government support of some "puerile" work; he criticizes scientific journals for printing ridiculous and disgraceful articles. He concludes that the "real working men in the way of science" should endeavor to raise their own scientific character for purposes of improving their reputation and gaining governmental support.]

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[8] James Fenimore Cooper, The American Democrat (Alfred A. Knopf, New York, 1931), 64.

[9] Joseph Henry to Alexander D. Bache, Aug. 9, 1838, in Nathan Reingold, ed., Science in Nineteenth-Century America, A Documentary History (Hill and Wang, New York, 1964), 83, 85.

4. At the close of the 19th century, Henry A. Rowland, a distinguished American physicist, addressed some advice to his colleagues of the newly formed American Physical Society in a statement entitled "The Highest Aim of a Physicist":[10]

> [Rowland claims that scientists are an aristocracy in the country by virtue of their intellect and ideals. He advocates rejecting such "foolish ideas as the equality of mankind" and describes the scientific mind as different from the ordinary in its ability to understand and cope with truth and error.]

5. The three mid-20th century statements which follow reflect Rowland's ideas in varying ways. The first spokesman, James B. Conant, originally a chemist and President of Harvard University, served the Federal government in numerous administrative and diplomatic posts.[11]

> [T] oday in the United States it is the uncommitteed investigator who stands in the greatest need of public support. He needs not only more money for his equipment and for helping hands but more public recognition for the significance of his work, for he is the scientific pioneer, the man who turns the unexpected corner, the laboratory man whose experiments mark the opening of a new era or the theorist whose ideas are so fruitful as to be revolutionary. By and large the United States has not yet produced its share of such scientific pioneers compared with Europe. . . .
>
> In the advance of science and its applications to many practical problems there is no substitute for first-class men. Ten second-rate scientists or engineers cannot do the work of one who is in the first rank.

6. James R. Killian, Jr. was science adviser to President Eisenhower when he made this statement:[12]

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[10] Quoted in Nathen Reingold, Science in Nineteenth-Century America, 324-326. (From SCIENCE IN NINETTENTH-CENTURY AMERICA by Nathan Reingold.

[11] National Science Foundation, Fifteenth Annual Report (Government Printing Office, Washington, 1965), ix.

[12] James R. Killian, Jr., "Research and Development in a Dynamic Economy," National Science Foundation, Proceedings of a Conference on Research and Development and Its Impact on the Economy (Government Printing Office, Washington, 1958), 161-162.

> I believe without qualification that more first-rate work is now done in the sciences in the United States than in any other country of the world. Our deficiency is at the very top, in the area over and above the first-rate, where the great intellectual breakthroughs occur, where the great concepts and discoveries originate that appear only a few times in each century. By heightening and broadening our efforts in basic uncommitteed research, we provide the best possible opportunity to bring about these achievements at the very top and to nurture the great men who will fortify and advance all of our efforts, both pure and applied.

7. The following excerpt is drawn from a report of the President's Science Advisory Committee:[13]

> In the advancement of science the best is vastly more important than the next best. Mediocre research is generally worse than useless, and the same may probably be said of teaching. It is, therefore, of first importance that national support for both activities should aim at sustaining and reinforcing outstanding work wherever it may be found. Both the Federal Government and university administrators should be firm in their support of what is first rate even when such support requires hard choices.

8. The following excerpt is from a campaign speech by Woodrow Wilson in 1912. Wilson at the time was President of Princeton University and had made a reputation as a noted historian.[14]

> [Wilson fears a "government by experts" which he claims, if it should come about, would make us no longer "free people."]

9. The following is excerpted from an article by A. H. Lauchner, a junior high-school principal:[15]

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[13] President's Science Advisory Committee, Scientific Progress, 14.

[14] John W. Davidson, ed., A Crossroads of Freedom: The 1912 Campaign Speeches of Woodrow Wilson (Yale University Press, New Haven, 1956), 83-84.

[15] Quoted in Richard Hofstadter, Anti-Intellectualism, 17-18.

> [The writer states than an aptitude for reading, writing, and arithmetic ought not to be expected in everyone, that children who do not perform well in the standard curriculum ought to be taught other things which will help them lead happy and useful lives.]

10. A survey conducted in the mid-1950's by the Commission on Human Resources and Advanced Training produced some relevant data:[16]

> That a significant proportion of our most capable young people is not completing college was pointed ou in the Commission's report as follows:
>
> > The United States wastes much of its talent. College graduating classes could be twice as large as they currently are, and with no loss of quality. The potential supply gets drained off, in large or small amounts, all the way through the educational system. Practically all potentially good college students enter, and most of them finish high school, but after high school the loss is large. ***Society fails to secure the full benefit of many of its brightest youth because they do not secure the education that would enable them to work at the levels for which they are potentially qualified.
>
> According to Commission estimates, of all the members of a typical age group, about 79 percent will enter high school; 58 percent will graduate from high school; 20 percent will enter college; and 12 percent will graduate from college.
>
> The average score of an age group is 100 on the Army General Classification Test (AGCT). This is roughly the same as an intelligence quotient of 100 as measured by similar tests. According to studies by the Commission on Human Resources and Advanced Training, AGCT scores of college graduates will average about 120.
>
> According to the data on educational achievement as presented by the Commission, about 19 percent of the age group will score 118 or above on the AGCT. Of this group, 98 per-

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[16] National Science Foundation, Scientific Personnel Resources (Government Printing Office, Washington, 1955), 66-67.

> cent will enter high school; 93 percent will graduate from high school; 44 percent will enter college; and 35 percent will graduate from college. In other words, about 65 percent of these capable students do not complete college. . . . Nearly half of the students with AGCT scores of 118 or above, and who graduate from high school, fail to enter college.

C. Political Elect and Scientific Elite

Perhaps no single event of recent times has so startled Americans as the Soviet Union's launching of the first earth satellites in 1957. One result was that large new expenditures of manpower and funds were soon pouring into American science. To some, the new policy seemed like a long-awaited vindication of Jefferson's pleas for support of the "natural aristocracy." But others became uneasy.

1. In 1961, after many years of military service and eight years as President, Dwight D. Eisenhower retired from public life. His "Farewell Address" was televised into millions of American homes.[17]

> [The President warns against allowing the "military-industrial complex" undue influence in government policy. The technological revolution has changed the character of this faction and caused the military-industrial group to command huge financial resources. While advocating a respect for science, Eisenhower advised that the nation ensure that a "scientific-technological elite" not be allowed to dictate public policy.]

2. Eisenhower's warning may be evaluated in light of the next group of selections, which presents a series of encounters between scientists and politicians over the past two decades, as well as raising certain

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[17] The New York Times, January 18, 1961, 22. (©1961 by The New New York Times Company. Reprinted by permission.)

other unstated questions.

The first speaker is United States Senator Maury Maverick, an outspoken Texan. He had been listening to several days of testimony extolling science. Finally he blew up at one of the scientists:[18]

> Without any tinge of sarcasm, it must be said that the doctor is a gentleman and a scholar of the first class, and a patriotic American.
>
> But he need not be so smug.
>
> I get a little tired of these hired hands of the monopolies and some of the professors, some of these bulldozing scientists, piously abrogating [sic] to themselves all the patriotism; I get tired of that. I get tired of their superior attitude. . . .
>
> Permit me to reassure the worthy doctors who piously lecture the politicians-- and lecture them a little.
>
> Why should they cast suspicion of their fellow Americans who have been shown public confidence by having been elected in a free democratic election? Are these scientists jealous of the politicians?
>
> Who was it who enacted the original National Academy of Sciences?
>
> The Congress, and Abraham Lincoln. . . .
>
> Let us speak of politicians. Who, for instance, was smart enough, and honest enough, to appoint Dr. Bowman to numerous scientific missions? A politician--and I might add, a statesman--named Franklin D. Roosevelt. Who appointed the great scientist, Dr. Vannevar Bush, to the Office of Scientific Research and Development? A duly elected public official, one Franklin D. Roosevelt.
>
> Who, indeed, had the thinking to offer the legislation before you for the creation of this scientific body? Politicians--like the gentlemen of this committee. . . .
>
> The moral character of politicians is just as high as the moral character of the American scientist. I say that deliberately--and I hope it will be heard by scientists everywhere, And I'm not sure but that the office holder has been, and is, more conscious of the public welfare than many scientists are. . . . The Congressional Record is public. Let the scientists make certain that the scientific record can be the same.

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[18] U.S. Congress, Senate, Subcommittee of the Committee on Military Affairs, Hearings on Science Legislation, 79th Cong., 1st Sess., 368-369.

> I do not wish to impugn even remotely the patriotism of the great scientists who have already appeared before you. Most of their testimony has been enlightening. But I suggest that all scientists remember there are other patriots in the world besides themselves and it would be a good idea to develop some social consciousness.
>
> Let us all bear in mind that we have a political Government and that our Constitution is a political instrument. The political character of our Government guarantees democracy and freedom, in which the people, through their Government, decide what they want. A scientist, because he receives $50,000 a year working for a monopoly, or a big business, must remember that this does not necessarily make him pure except that he may be a pure scientist.

3. The special frustrations which politicians face in dealing with scientific problems are epitomized in the testimony of Charles E. Wilson, Secretary of Defense in the Eisenhower administration. Wilson, the practical-minded ex-president of General Motors, had been summoned to testify about his purported reluctance to allocate funds for pure research, even in such vital defense areas as radar, nuclear propulsion, missiles, and electronics.[19]

> Important research is going on in all those areas. . . .
>
> On the other side, it is very difficult to get those men who are trying to think out ahead all the time to come down to brass tacks and list the projects and what they expect to get. . . . They would just like to have a pot of money without too much supervision. . . .
>
> In the first place, if you know what you are doing, why it is not pure research. That complicates it.

4. But the problem runs both ways. Bentley Glass, one of America's most distinguished biologists made the following observation:[20]

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[19] U. S. Congress, Senate, Committee on Armed Services, Hearings, XVI, 84th Cong., 2nd Sess., 1742, 1744.

[20] Bentley Glass, "The Academic Scientist, 1940-1960," Science, 132 (Sept. 2, 1960), 602. (Copyright 1960 by the American Association for the Advancement of Science.)

> [The writer observes that it is seemingly easier to classify a document as "top-secret" than it is to declassify one. He gives as an example his own report of ten years earlier, classified "top-secret," which he is now not allowed to see, and which is uselessly out of date.]

5. An historian of science noted some signs of changing relationships between scientists and politicians:[21]

> [The selection discusses the awarding of the Fermi Prize for work in atomic energy, given by the Atomic Energy Commission. The writer describes the conflict of political figures and scientists in the matter of choosing a recipient, and in other areas, such as in the formulation of the test ban agreement of 1963. The writer claims that people today do not have unlimited faith in the ability of the scientist.]

D. Democratic Science and Totalitarian Science

As we have already noted, the challenge presented by the Soviet Union's rapid strides in science and technology has provided a potent stimulus for Federal support of science in recent years. That challenge has also raised troubling questions related to the basic problem considered in this section: is democracy the best form of government for ensuring scientific progress?

1. This problem came under active discussion early in World War II. Senator Harley M. Kilgore of West Virginia had drafted a bill to mobilize scientists and engineers for the war effort. One of those summoned to testify was Waldemar Kaempffert, science editor of The New York Times.[22]

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[21] Daniel S. Greenberg, "The Myth of the Scientific Elite," The Public Interest, Number 1 (Fall 1965), 59, 61-62.

[22] U. S. Congress, Senate, Subcommittee of the Committee on Military Affairs, Hearings on Technological Mobilization, 77th Cong., 2nd Sess., I, 67-69, 71-72.

MR. KAEMPFFERT: . . . We have followed in scientific and industrial research what the economists call the laissez faire policy which is now outmoded in economics but which still prevails in research.

Industrial progress has been made in a haphazard way and in all countries, with the exception of Soviet Russia, research has grown up like Topsy; there has been no concentrated social purpose in planning, no direction, no organization, except since this war. . . .

We have made enormous progress in physics and chemistry, because the profits lie there and the military advantage lies there, but after all, science must serve much larger--a much larger purpose than that, and the only government in the world, I regret to state, that has used science, or intended to use science to secure social security, social happiness and contentment, is Russia.

Now, I strongly disapprove of anything like the imposition of a state philosophy or ideology upon every shade of human thinking of the kind that you have in Russia.

On the other hand, I have nothing but admiration for the organization of science such as constituted in Russia. There you find that science is propagated on all fronts.

SENATOR KILGORE: Whether it is profitable or not?

MR. KAEMPFFERT: Irrespective of whether there is any profit in it. The Soviet Academy of Sciences, which is the equivalent of our National Academy of Sciences, is an integral part of the Government, and as much so as our Department of Agriculture or Department of Commerce. It plans the research activities of the entire country, and those plans extend right down into every shop. The result was that Russia found it least difficult of all the nations to turn over from peace to war.

They were already mobilized scientifically, whereas we were not, and not even the Germans as completely as they became in about 1936 or so.

So that we have at least an example there of what can be done sfor a purely social purpose. . . .

The example that has been set by Russia and by our own industrial laboratories indicates plainly enough that technological progress can be made only in competent planning, direction

> and organization, all of which you provide for, I am glad to see, in your bill. I do not mean to say that we must dictate what we want, and then get it. We should also receive projects from inventors and fit them into the plan where they can be fitted, and encourage them. But, there must be continuity of work; it must follow some plan. . . .
>
> I should like to see scientific research and technology organized in this country largely for social purposes. Now, we are starting in on that already. We are making what is to my mind an extremely important experiment in the Tennessee Valley Authority. We should broaden that out, much as you have broadened it out in your bill, and make it a permanent institution which shall give industrial and scientific research a social purpose and direction under competent men, and which shall also get rid of the enormous amounts of duplicated effort in our governmental scientific bureaus here, and which shall encourage invention in a new way by guiding it or telling it what it should do.

2. Fifteen years later the problem was still under discussion. The National Science Foundation compiled some pertinent evidence:[23]

> From published Russian sources, it appears that some 24,000 scientists, or about 14 percent of Soviet scientific manpower, devote their time to basic research. This figure is probably somewhat higher, say between one-fifth and one-third, than the number of scientists--on a full-time equivalent basis--engaged in basic research in the United States. The Soviet Union spent more than 11.6 billion rubles on research and development in 1955, somewhat in excess of 1 percent of its gross national product, and the proportion that went to basic research is unknown. However, the proportion is presumably less than that based on manpower estimates. These and other facts suggest the following picture:
>
> 1. A remarkably high rate of industrial and technological growth, as indicated by the high rate of increase in gross national product.
>
> 2. An even greater relative increase in research and development, as indicated by the increasing ratio of research and development to gross national product.

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[23] National Science Foundation, Basic Research: A National Resource (Government Printing Office, Washington, 1957), 45-46.

> 3. A country still technologically underdeveloped, as indicated by the low starting level of its research and development--and the low level which still prevails--relative to the United States.
>
> 4. A relatively heavy emphasis on basic research, certainly heavy if compared with the United States, but differing from our situation in the authoritarian controls exercised in a dictatorship. . . .
>
> It would appear that the United States has a formidable competitor in the Soviet Union which, although starting from a relatively low research-and-development level, is progressing at a remarkably rapid rate. In addition to stressing technological aspects of its economy, the Soviet Union seems to be able to draw heavily on an educational and intellectual structure, developed long before the coming of the present political regime, closely resembling European structures with a strong emphasis on basic research. There is also evidence of able, high-ranking administrative leadership toward increasing the stature of the country in science and technology.
>
> The Soviet situation may well produce a more effective balance between basic research and applied research-development than that existing in the younger and more technologically oriented system of the United States. As we continue the effort to maintain our relative position, indeed to excel, in basic research, we must remain aware of the large reservoir of untapped manpower in the Soviet Union and the availability of ample funds for the support of future scientists and engineers.
>
> Forces of a political nature may exert some effect in working against these positive tendencies. Yet a rather effective atmosphere exists in the Soviet Union for the education and use of capable, devoted scientists with less interest in the immediate applications of science. Such a situation is likely to give the United States a short-run advantage in technology. But if this country is not to suffer in the long run, it must act upon the principle that progress in applied research and development depends absolutely on the growth and encouragement of basic research.

3. In 1962 a Defense Department physicist noted some significant differences between the Soviet and the American outlook:[24]

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[24] George C. Sponsler, "Needed: Scientists on Top," Bulletin of the Atomic Scientists, XVIII (June, 1962), 17. (Copyright 1962 by the Educational Foundation for Nuclear Science, 935 E. 60th Street, Chicago, Ill., 60637)

> [The writer states that a majority of high rulers in the U.S.S.R. have had scientific training while the preponderance of U.S. officials are drawn from the ranks of business and law. The US.S.R. coordinates scientific activity while scientific effort here is managed by a large number of overlapping governmental agencies and private organizations. The writer attributes the rapid growth of technology and industry in the U.S.S.R. to central planning.]

4. Following is a direct confrontation of typical Soviet and American claims:[25]

> [A Soviet spokesman states that under the leadership of the Communist Party his countrymen can expect even more spectacular feats than Sputnik; he is confident that the socialist system brings out "the most notable talents" of its citizens. An American, connected to the Brookhaven National Laboratory comments that the freedom enjoyed in this nation is a great advantage; it challenges without demanding. In a system such as ours, he claims, the individual, not the government, "determines the competence of the system."]

5. In a letter to the editor of Science magazine an American biologist discusses the problem from a broad historical point of view:[26]

> [The writer discusses the issue of whether democracy is the best setting for science. In the 19th century one could, he explains, make a good case for the superiority of a monarchy as a home for science. American scientists in general like democracy and science and tend to see them as necessarily linked but he points to other forms of government in which science advanced significantly. He claims that the traditions of a society, rather than a specific form of government, determine the fate of its scientific endeavor. Independent inquiry must be possible he maintains for the advancement of science and he hopes that totalitarian governments which now support science and allow such inquiry, although often qualified, will in turn be permeated by scientific, and therefore liberal, thought. Edsall concludes that democracy has fostered science but is not necessarily the only form of government which could encourage advancement in this area.]

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[25] Gerald Holton, "Scientific Research and Scholarship," Daedalus, 91, 2 (Spring, 1962), 376. (The American Academy of Arts and Sciences.)

[26] John T. Edsall, Science, 137 (Aug. 10, 1962), 456-458. (Copyright 1962 by the American Association for the Advancement of Science.)

SECTION III

"PRACTICAL" AMERICANS AND "PURE" SCIENTISTS

If there is any validity in the concept of the "typical American," one major element in it would probably be a preference for the practical over the theoretical. According to tradition Americans are highly inventive and ingenious, but more so in the real world of machines than in the abstract one of ideas. The stereotyped American seeks workable solutions to specific problems, rather than long-range theories about broad categories of problems. This section presents evidence relating to this traditional image of Americans, as a basis for determining what effect, if any, the propensity for being "practical" has had upon the progress of American science and technology.

A. *The Uses and Abuses of Science*

Few concepts are as hotly debated by philosophers and scientists as that of the proper goals of science. Americans have contributed a variety of notions to this ongoing debate.

1. Benjamin Franklin is often portrayed as a clever inventor of practical devices such as lightning rods and bifocal eye-glasses but a mere dabbler in science. Actually, in the field of physics, he made fundamental contributions which earned him the respect of the leading scientists of his time. Here, in his deceptively simple, homespun style, he stated his concept of the objectives of science:[1]

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[1] Benjamin Franklin, *Experiments and Observations on Electricity* (London, 1769), 62 in I. Bernard Cohen, ed., *Benjamin Franklin's Experiments* (Harvard University Press, Cambridge, 1941), 229.

> [Franklin contends that for practical purposes we need only know the laws of nature; understanding how the laws work is a matter of "speculation," pleasant to know but inessential.]

2. Jefferson, too, helped establish the traditionally "American" philosophy of science.[2]

> [The author quotes Jefferson as recommending that chemists turn their attention to the domestic sphere and attempt to improve baking, brewing, etc. However Jefferson held scant regard for geology; such study he considered useless, time-consuming, and speculative.]

3. In what may be the most celebrated critique of America ever written by a foreigner, the French observer Alexis de Tocqueville, commented on American character and culture in the 1830's.[3]

> It must be acknowledged that in few of the civilized nations of our time have the higher sciences made less progress than in the United States; and in few have great artists, distinguished poets, or celebrated writers, been more rare. Many Europeans, struck by this fact, have looked upon it as a natural and inevitable result of equality; and they have thought that, if a democratic state of society and democratic institutions were ever to prevail over the whole earth, the human mind would gradually find its beacon-lights grow dim, and men would relapse into a period of darkness.
>
> To reason thus is, I think, to confound several ideas which it is important to divide and examine separately: it is tomingle, unintentionally, what is democratic with what is only American. . . .
>
> In America, every one finds facilities unknown elsewhere for making or increasing his fortune. The spirit of gain is always on the stretch, and the human mind, constantly diverted from the pleasures of imagination and the labors of the intellect, is there swayed by no impulse but the pursuit of wealth. Not only are manufacturing and commercial classes

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[2] Edwin T. Martin, *Thomas Jefferson: Scientist*, 44-45, 45-46. [Footnotes omitted.]

[3] Alexis de Tocqueville, *Democracy in America* (Sever and Francis, Cambridge, Mass., 1862), II, 41-42, 46.

> to be found in the United States, as they are in all other countries; but, what never occurred elsewhere, the whole community are simultaneously engaged in productive industry and commerce.
>
> But I am convinced that, if the Americans had been alone in the world, with the freedom and the knowledge acquired by their forefathers, and the passions which are their own, they would not have been slow to discover that progress cannot long be made in the application of the sciences without cultivating the theory of them. . . .
>
> But at the very time when the Americans were naturally inclined to require nothing of science but its special applications to the useful arts and the means of rendering life comfortable, learned and literary Europe was engaged in exploring the common sources of truth, and in improving at the same time all that can minister to the pleasures or satisfy the wants of man.
>
> The position of the Americans is therefore quite exceptional, and it may be believed that no democratic people will ever be placed in a similar one. Their strictly Puritanical origin,--their exclusively commercial habits,--even the country they inhabit, which seems to divert their minds from the pursuit of science, literature, and the arts,--the proximity of Europe, which allows them to neglect these pursuits without relapsing into barbarism,--a thousand special causes, of which I have only been able to point out the most important,--have singularly concurred to fix the mind of the American upon purely practical objects. His passions, his wants, his education, and everything about him, seem to unite in drawing the native of the United States earthward. . . .
>
> In America, the purely practical part of science is admirably understood, and careful attention is paid to the theoretical portion, which is immediately requisite to application. On this head, the Americans always display a clear, free, original, and inventive power of mind. But hardly any one in the United States devotes himself to the essentially theoretical and abstract portion of human knowledge. In this respect, the Americans carry to excess a tendency which is, I think, discernible, though in a less degree, amongst all democratic nations.

4. Henry A. Rowland, the 19th century American physicist whose views on another subject were noted earlier, depicted American attitudes

prevalent in 1899:[4]

> [Rowland contends that pure science and research can be vitally important to the well-being of men and should be supported. Beyond its practical application, research can lead men to an understanding of nature, and it is this knowledge which will finally bring the greatest good and happiness to mankind.]

B. *Study in Contrasts*

The next group of documents deals with two sharply contrasting major figures of 19th-century American science and invention: the most prolific technological innovator the world has yet produced, Thomas A. Edison, and the little-known but highly important mathematical physicist, J. Willard Gibbs.

1. In the 1870's Edison was struggling to develop a device that would increase the number of words per minute transmitted by telegraph. A young telegraph engineer who worked with him described Edison's methods:[5]

> [After unsuccessful investigation of theoretical writings on his problem, Edison utterly emersed himself in a study of chemistry, experimented incessantly, and after six weeks completed his task successfully.]

2. Edison had not quite perfected the electric light when he released this typical statement to the newspapers:[6]

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[4] Quoted in Nathan Reingold, *Science in Nineteenth-Century America*, 324, 327-328.

[5] J. B. McClure, *Edison and His Inventions* in Matthew Josephson, *Edison, A Biography*, 94.

[6] New York *Sun*, Sept. 16, 1878, in Matthew Josephson, *Edison, A Biography*, 183.

> [Edison claims that his solution was simple and that his success was due to the originality of his thinking.]

3. An oft-quoted anecdote seems to demonstrate what Edison thought of scientific theorists:[7]

> [Edison's trick, played on a mathematician, is described. Edison presented a light bulb to the theoretician and asked him to determine its capacity. When the young man was well into his calculations, Edison reminded him that he had merely to fill the lamp with a liquid, pour out the liquid and measure it in a calibrated container. Edison was fond of his "rule-of-thumb" method.]

4. A commonly overlooked facet of Edison's work is his one major contribution to pure science, his discovery of the "Edison Effect" involving the emission of electrons by heated filaments in light bulbs. He never pursued this discovery, however, and inquiries about it by scientists and others evoked responses such as the one below:[8]

> [Edison responds, in jocular fashion, that he had had little time and taste for the "aesthetic" aspect of his work.]

5. In 1879, a British commission declared that Edison's announced plan for an electric power system to light a whole community was a scientific impossibility, but one member of the commission, the distinguished physicist John Tyndall, added an interesting comment:[9]

> [Tyndall explains that Edison had great talent for relating facts and principles and for devising "novel and concrete combinations."]

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[7] Matthew Josephson, *Edison, A Biography*, 193.

[8] W. C. White, "Electrons and the Edison Effect" in Matthew Josephson, *Edison, A Biography*, 278-279.

[9] T. C. Martin, *Forty Years of Edison Service* in Matthew Josephson, *Edison, A Biography*, 197.

6. Edison had some intriguing notions of his own about the nature of scientific and technological innovation. Note his use of such key words as "theory," "discovery," "invention."[10]

> Edison has often been spoken of as a discoverer; and in one sense he may appear to have discovered things by reaching out into the realm of what to other persons was the unknown. But he himself dislikes the term as applied to himself. "Discovery is not invention," he once said to me, "and I dislike to see the two words confounded. A discovery is more or less in the nature of an accident. A man walks along the road, say from the laboratory here to Orange station, intending to catch the train. On the way his foot kicks against something, and looking down to see what he has hit, he sees a gold bracelet embedded in the dust. He has discovered that, certainly not invented it. He did not set out to find a bracelet, yet the value of it is just as great to him at the moment as if, after long years of study, he had invented a machine for making gold bracelets out of common road-metal.
>
> "Goodyear discovered the way to make hard rubber. He was at work experimenting with India-rubber, and quite by chance he hit upon a process which hardened it--the last result in the world that he wished or expected to attain. Bell's telephone was a discovery too, not an invention. He was engaged with the possibilities of sending sound waves over a telegraph wire, and filed an invention by which this could be done. Then, by accident, it was discovered that articulate speech could be sent over the wire--and there was the telephone. But Bell did not set out to make an instrument by which talk could be transmitted, and therefore I say he discovered instead of inventing the telephone. In a discovery there must be an element of the accidental, and an important one too; while an invention is purely deductive. An abstract idea or a natural law, I maintain, may be invented; for, in my opinion, Newton invented but did not discover the theory of gravitation. He had been at work on the problem for years, and had no doubt invented theory after theory to which he found it impossible to fit his facts. Then he constructed the theory to which all facts corresponded, and thus invented it by deductive reasoning. Of course the old story of the apply dropping from a tree, and Newton's jumping up with a species of 'Eureka,' I reject absolutely.
>
> "It is too much the fashion to attribute all inventions to accident, and a great deal of nonsense is talked on that score.

---

[10] George Parsons Lathrop, "Talks with Edison," Harper's New Monthly Magazine, LXXX (1890), 432-434.

"In my own case but few, and those the least important, of my inventions owed anything to accident. Most of them have been hammered out after long and patient labor, and are the result of countless experiments, all directed toward attaining some well-defined object. All mechanical improvements may safely be said to be inventions and not discoveries. The sewing-maching was an invention. So were the steam-engine and the typewriter. Speaking of this latter, did I ever tell you that I made the first twelve typewriters, at my old factory in Railroad Avenue, Newark? This was in 1869 or 1870; and I myself had worked at a machine of similar character, but never found time to develop it fully." . . .

Not long ago I asked Mr. Edison which of his inventions had caused him the greatest amount of study, and required the most elaborate experiments.

He replied, promptly: "The electric light. For, although I was never myself discouraged, or inclined to be hopeless of success, I cannot say the same for all of my associates. And yet, through all those years of experimenting and research, I never once made a discovery. All my work was deductive, and the results I achieved were those of invention pure and simple. I would construct a theory and work on its lines until I found it was untenable. Then it would be discarded at once, and another theory evolved. This was the only possible way for me to work out the problem, for the conditions under which the incandescent electric light exists are peculiar and unsatisfactory for close investigation. Just consider this: We have an almost infinitesimal filament heated to a degree which it is difficult for us to comprehend, and it is in a vacuum, under conditions of which we are wholly ignorant. You cannot use your eyes to help you in the investigation, and you really know nothing of what is going on in that tiny bulb. I speak without exaggeration when I say that I have constructed three thousand different theories in connection with the electric light, each one of them reasonable and apparently likely to be true. Yet only in two cases did my experiments prove the truth of my theory. My chief difficulty, as perhaps you know, was in constructing the carbon filament, the incandescence of which is the source of the light. Every quarter of the globe was ransacked by my agents, and all sorts of the queerest of materials were used, until finally the shred of bamboo now utilised by us was settled upon. Even now," Mr. Edison continued, "I am still at work nearly every day on the lamp, and quite lately I have devised a method of supplying sufficient current to fifteen lamps with one horse-power. Formerly ten lamps per horse-power was the extreme limit."

7. It would be hard to imagine a greater contrast between two men than that presented by Thomas A. Edison and J. Willard Gibbs. Every

American schoolboy will readily identify Edison; few Americans have ever heard of Gibbs. Yet all authorities agree that Gibbs was probably the most important American scientist of the 19th century. His highly abstruse work in thermodynamics and statistical mechanics revolutionized those branches of physics, and he virtually created the new science of physical chemistry. Vital techniques used today in the chemical, metallurgical, and other basic industries have been derived from discoveries made by Gibbs. Doubtless his obscurity is partly due to his own extremely reticent personality, but it may also reflect certain realities of American life.

In the period from 1871 to 1879, Gibbs did much of his most significant work while on the Yale faculty. Although he had won considerable esteem abroad, his status in his own country may be inferred from the fact that Yale paid him no salary whatsoever. Then, in a letter dated May 8, 1879, the noted physicist Henry Rowland recommended Gibbs to President D. C. Gilman of Johns Hopkins University:[11]

> [Rowland recommends that Willard Gibbs be hired to teach Mechanics and Mechanical Drawing. He claims that Gibbs is unusual in that he can grasp, in addition to the mathematics, all other aspects of his subject.]

8. When Johns Hopkins offered Gibbs a moderately paid professorship, James Dwight Dana, a leading geologist and friend of Gibbs at Yale, expressed the feelings of some of Gibbs's colleagues:[12]

> [Dana implores Gibbs to remain at Yale. He recognizes the discouragement Gibbs might have felt there and suggests that some form of payment for Gibbs might be arranged.]

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[11] Quoted in Nathan Reingold, *Nineteenth-Century American Science*, 317-318.

[12] Nathan Reingold, *Nineteenth-Century American Science*, 318.

9. The Secretary of Yale College, Franklin B. Dexter, addressed the following letter to Gibbs:[13]

> [Dexter writes to Gibbs that it will be recommended to the Corporation that Gibbs be paid in the future and that his teaching program be altered to allow him more freedom of scope.]

10. Gibbs expressed his decision in a letter to the president of Johns Hopkins:[14]

> [Gibbs reports that he cannot break his ties with New Haven, especially in light of recent developments.]

11. The director of research of the United States Steel Corporation stated the high regard a twentieth-century practical man held for Gibbs, the theoretician. The "phase rule" is a fundamental law of physics discovered by Gibbs in the 1870's:[15]

> [The writer explains that Gibbs's theoretical work of twenty-five years earlier is now extremely valuable in solving problems in metallurgy. He recommends the support of "high-brow" ideas, arguing that some current theoretical work may, in the future, have important practical application.]

12. Another comment on Gibbs and perhaps, on the status of many abstract scientists in America, is offered by an executive of the telephone industry, which also owes a considerable debt to Gibbs:[16]

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[13] _Ibid._, 318-319.

[14] _Ibid._, 319.

[15] John Johnston in Muriel Rukeyser, _Willard Gibbs_ (Doubleday, Doran and Company, Garden City, N. Y., 1942), 367. (From the book WILLARD GIBBS by Muriel Rukeyser. Copyright 1942 by Muriel Rukeyser. Dutton Paperback Edition. Reprinted by permission of E. P. Dutton & Co., Inc.)

[16] F. B. Jewett in Muriel Rukeyser, _Willard Gibbs_, 422.

> [The writer has difficulty in stating accurately the importance of Gibbs's work; it is utterly fundamental to modern communication and pervades all aspects of it.]

13. How would Edison and Gibbs have fared in mid-20th century America? In 1940, with World War II under way in Europe, one of the steps taken by the Federal government to meet the defense emergency was the establishment of a National Inventors Council. The hope was that it would in the words of Secretary of Commerce Harry Hopkins, "muster American inventive genius in the cause of national welfare, defense and security." But the results were extremely disappointing. In 1942 the Senate decided to investigate this unexpected failure, and among those summoned to testify was Waldemar Kaempffert, science editor of *The New York Times*.[17]

> We had, in the last war, considerable experience in tapping the country's inventive ingenuity. You will remember, we had the Naval Consulting Board, of which Thomas A. Edison was the head. That organization was primarily concerned with dealing with the submarine menace, and it welcomed ideas from anyone. We cherished the illusion that a nation which had produced Morse, McCormick, Bell, and others--hundreds of other important inventors--could surely solve this problem. . . .
>
> Now, we come to our Inventors' Council. There is no question but that the public demands the Inventors' Council and there is no question but that we need it. We should tap inventive ingenuity wherever it is to be found, yet I have no great faith in it, simply because of the character of modern technology.
>
> The time has gone, I think, when we can rely on the heroic inventor of the Morse or the Bell or the Edison type. The problems are too vast and intricate.
>
> I think we shall always have the lone garret inventor with us, but I think he is going to give us fountain pens, vacuum cleaners, and contrivances of that kind. When it comes to problems like those involved in metallurgy or illumination or synthetic rubber, your lone garret inventor is simply hopelessly lost. . . .

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[17] U.S. Congress, Senate, Subcommittee of the Committee on Military Affairs, *Hearings on Technological Mobilization*, 77th Cong., 2nd Sess., I, 67-69, 71-72.

> Nothing is so impractical as your practical man. If you want a flounderer, an inefficient and inept person, give me your practical inventor every time. A good theory that works means far more to an inventor than empirical tinkering. We got the airplane from the Wright brothers not because they were tinkerers but because they conducted theoretical experiments in wind tunnels. We got the modern electric lamp which Edison left in a very crude state because of the theoretical work done by men like Coolidge and Langmuir of the General Electric Co. We got nylon not through tinkering but through developing a theory of polymerization.

C. Theoretical Distinctions and Practical Politics

At this point it might be helpful to look more closely into the theoretical differences between pure and applied work in science. Certain problems stemming from these differences, as we shall see, are sometimes anything but theoretical.

1. The author of this statement directed all Federal science activities in World War II:[18]

> The distinction between applied and pure research is not a hard and fast one, and industrial scientists may tackle specific problems from broad fundamental viewpoints. But it is important to emphasize that there is a perverse law governing research: Under the pressure for immediate results, and unless deliberate policies are set up to guard against this, *applied research invariably drives out pure*.
>
> The moral is clear: It is pure research which deserves and requires special protection and specially assured support.

2. The end of World War II brought new problems to the fore:[19]

> J. Robert Oppenheimer, wartime director of the Los Alamos Scientific Laboratory, later testified that "we learned a lot during the war," and his words might well have been echoed

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[18] Vannevar Bush, *Science the Endless Frontier. A Report to the President on a Program for Postwar Scientific Research* (Government Printing Office, Washington, 1945), 83.

[19] National Science Foundation, *Fifteenth Annual Report*, vii.

> by many others. "But," he continued, "the things we learned (were) not very important. The real things were learned in 1890 and 1905 and 1920, in every year leading up to the war, and we took this tree with a lot of ripe fruit on it and shook it hard and out came radar and atomic bombs. . . . The whole spirit was one of frantic and rather ruthless exploitation of the known; it wasnot that of the sober, modest attempt to penetrate the unknown." Thus it may be said in a sense that technology was treading on the heels of science when the war ended.

3. A General Electric research executive explained how the difference works out in an industrial laboratory:[20]

> The distinction between basic and applied research as depending on motivation has led to the following attitude on the part of the research scientist toward management; if you want me to do it, it's applied; if I want to do it myself, it's basic.

4. A former presidential science advisor George B. Kistiakowsky of the National Academy of Sciences, pointed to a common source of difficulty:[21]

> In trying to assess the value of science, a problem which we all encounter and which is a perennial problem of course, is that the results of scientific work and their value to society are totally unpredictable.
>
> There are so many examples of this problem that I will mention only one. When Dr. Towns was studying the microwave spectrum of ammonia it was a highly esoteric subject--almost in the same class as the question as to why grass is green. . . . And yet, directly out of this study of the microwave spectrum of ammonia grew the maser and the laser. Examples such as this can be multiplied a hundredfold.

5. The next two documents show just how concrete and controversial these distinctions can be. The first, published in 1957, became the

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[20] Malcolm H. Hebb, "Basic Research at General Electric Company," National Science Foundation, *Proceedings of a Conference on Academic and Industrial Basic Research* (Government Printing Office, 1960), 21.

[21] U.S. Congress, House Committee on Science and Astronautics, *Hearings on Basic Research and National Goals*, 89th Cong., 1st Sess., 10.

basis of Federal policy for nearly a decade.[22]

> [B]asic research--an expression of man's desire, his need to learn and explore--and, quite incidentally from one standpoint, the source of all technological progress. As a continuing search for new knowledge, basic research has certain characteristics which help us distinguish it from other forms of scientific activity. The search is systematic, but without direction save that which the investigator himself gives it to meet the challenge of the unknown. He is strictly on his own, guided primarily by his interest in learning more about the workings of nature.
>
> His work may be contrasted with that of scientists and engineers conducting applied research (laboratory studies concerning the practical use of newly found knowledge) or development, which takes applied research out of the laboratory and translates it into production. In applied research and development an unexpected problem is essentially a negative thing. It represents a source of delays, an obstacle to be overcome, preferably in the not-too-distant future. Work proceeds under pressure to solve or circumvent the problem as quickly as possible because it interferes with the attainment of practical goals. Knowledge of the most fundamental sort may be needed and sought, but, as one engineer has put it, "not too much knowledge." Ideally, one would acquire only sufficient knowledge to solve the problem at hand, although the stopping point may not be easy to determine. But the practical goal and the time element are always there.
>
> For the scientist specializing in basic research an unexpected problem is also an obstacle to be overcome. But it is a good deal more than that. In a fundamental sense it is the reason for his existence. Perhaps whe will solve the problem. But the effort may take years or his entire career, and he knows he may never find a solution. If he does, he will soon seek new problems worthy of his mettle. The unexpected is what he thrives on. The odds are that work which proceeds too long without involving the unexpected, the element of surprise, is not fruitful work. . . . Since funds are limited, why should the claims of basic research be met more fully than, say, the claims of the humanities or mass public recreation or under-developed countries or psychological warfare?
>
> As Federal funds for basic research increase, we find an increasing interest in possible ways of evaluating the tangible returns which the American taxpayer has received and may expect to receive for his money. Such a desire is

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[22] National Science Foundation, Basic Research: A National Resource, 1-2, 61-63.

> understandable and must be recognized. However, because of the nature of basic research, any attempt at immediate quantitative evaluation is impracticable and hence not realistic. Basic research would lose its potency in adding significantly to knowledge and understanding of nature, if it were circumscribed by the requirement that it justify its cost to the taxpayer by proving its value through immediate practical benefits. . . .
>
> Basic research is so closely identified with cultural as well as technological progress that this alone provides sufficient reason for doing and supporting it.
>
> In the long run, basic research pays off in the most practical terms, as some industrial laboratories have found by their policy of calculated investment risks. It took years of basic research before the Bell Telephone Laboratories developed the transistor, for example. But direct and immediate links between basic research and its application are extremely rare.
>
> So regular efforts to appraise quantitatively the practical results of Federal projects might . . . encourage both Federal administrators and scientists to concentrate on work most likely to pay off in the short run--and bias our scientific effort still further toward applied research and development.

6. President Lyndon B. Johnson summoned the nation's medical leaders to a meeting at the White House in June, 1966, and made the following announcement:[23]

> [The President announces a forthcoming meeting he is calling of men concerned with research and with public health. He explains that he intends to encourage the application of medical discoveries to the combating of fatal diseases, in order to prolong the lives of our citizens.]

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[23] Science, 153 (July 8, 1966), 149-151. (Copyright 1966 by the American Association for the Advancement of Science.)

SECTION IV

"THE BUSINESS OF AMERICA IS BUSINESS"

So said President Calvin Coolidge in the 1920's, and certainly the history of the preceding half-century offered evidence to bear him out. Too often overlooked, however, is the extent to which the rise of big business depended on progress in science and technology, and as relations between business and science became increasingly intimate and complex, each side often resented and misunderstood the other's motives and methods. Eventually new relationships were worked out which, though periodically subject to strain, produced the science-conscious, machine-based America of the present.

1. No individual played a larger role in these developments than Edison. His first major involvement with big business connected him with one of the corporate giants of the post-Civil War era, Western Union.[1]

> [The writer explains that as a young man Edison was paid for his work by a company which then took control of the resulting product. In his journal Edison referred to these men as "small-brained capitalists."]

2. At one point in his career, Edison became involved in the struggle between Western Union and the fabulous speculator Jay Gould for control of the telegraph industry. Following is Edison's opinion of both sides:[2]

> [Edison expresses contempt for the conscience of Gould, and the brains of both parties.]

3. Alexander Graham Bell, too, had his difficulties with the financial tycoons:[3]

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[1] Matthew Josephson, Edison, A Biography, 86-87.

[2] Ibid., 126.

[3] Ibid., 141.

> [Fearful of short-run financial losses, Orgon of Western Union rejected Bell's proposal for developing his telephone.]

4. Edison made a number of major contributions to telephone technology. He had this to say of the capitalists in that field:[4]

> [M]any extremely useful improvements on the telephone are in the possession of those controlling the invention, and are safely locked up from the world because of the great extra expense which would attend their application to existing instruments.

5. In October, 1878, Edison was on the verge of perfecting the electric light. But awesome problems remained unsolved, most notably the design of a system capable of producing and transmitting sufficient electric power to light up whole communities. As we have seen, renowned scientists had flatly declared this impossible. At this juncture Edison received financial support under conditions which foreshadowed a new relationship between men of business and men in laboratories:[5]

> [The writer explains that in an historic and most unusual move the Western Union company, backed by Morgan, bought from Edison an unknown entity, a lighting system still undeveloped. The contract provided for an organization under Edison to work on the project.]

6. Out of the new relationship developed by Edison and other innovators with the businessmen came a new institution, one of the chief vehicles of scientific achievement in 20th century-America, the industrial research laboratory. In the following excerpt one of the scientific pioneers of the telephone industry, who for several decades headed the famed Bell

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[4] Quoted in George P. Lathrop, "Talks with Edison," Harper's New Monthly Magazine, LXXX (Feb., 1890), 437.

[5] Matthew Josephson, Edison, A Biography, 189-190.

Telephone Laboratories candidly emphasizes the profit motive underlying such institutions. The paradox to be resolved here lies in the fact that a large part of the research performed in the laboratory under this spokesman's supervision was not (and still is not, today) restricted to direct development of new telephonic devices and improvements, but ranged into the most abstract realms of pure science.[6]

> [The writer contends that money invested properly in pure research is returned to industry many times over in the form of improved marketable products.]

7. The electrical industry also produced its major laboratories--and major contributions to pure science. Irving Langmuir's many years of work at the General Electric Laboratory won him the Nobel Prize in 1932. In an article written in 1938 he elucidated some of the links between pure and applied science--and between both and profit-making:[7]

> [Langmuir describes conditions during the first part of the 20th century in which the major scientific effort was the application of knowledge. At this time the General Electric Company established a laboratory devoted to fundamental research which was not aimed at definite goals. Langmuir recounts his own experience in this laboratory in which he was free to follow his own interests; his work was however ultimately applicable to the manufacture of lamps.]

8. Another way of looking at the problem is suggested by one of today's General Electric scientists:[8]

> [This subject of benefits from basic research puts me in mind of a story. It's about a man who visited a small

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[6] J. J. Carty, "The Relation of Pure Science to Industrial Research," Science, N.S. XLIV (1916), 511-516.

[7] Irving Langmuir, "Fundamental Research and Its Human Value," Scientific Monthly, XLVI (1938), 358-362.

[8] Malcolm H. Hebb, "Basic Research at General Electric Company," 22-23.

town and saw evidences of amazing marksmanship all about -- on trees, barns, and fences, each with a bullet hole in the exact center. He asked to meet the expert shot. It turned out to be the village idiot. "This is sensational. How in the world did you do it?" asked the visitor. "Easy as pie," was the answer. "I shoot first and draw the circles afterward."

The General Electric Company has several flourishing businesses that are directly traceable to basic research in our Research Laboratory. For some years we have had a program of high pressure research aimed at studying phase transitions and states of matter at high temperatures and pressures. Out of this came the discovery of synthetic diamonds and Borazon or cubic boron nitride. Following the discovery immediate efforts were made to put it to practical use, and a phenomenally rapid transition from the laboratory to production occurred. From the first announcement of laboratory diamonds to the first commercial sale was less than 2 years. Today, synthetic diamonds in most industrial grades are fully competitive with natural boart.

The silicone business is another business considerably older that stemmed from basic research in our Laboratory. Silicones had no commercial significance when the investigation into their chemical properties was begun. The breakthrough for application came with the discovery of direct synthesis starting from elemental silicone. By comparison with diamonds, the silicone business developed very slowly. It took about 8 years from the first laboratory breakthrough to the start of a commercial silicone business.

9. Here are some excerpts from a nationwide study of big business laboratories.[9]

[The writer reports the results of his attempt to determine the quality of corporation scientists. The majority of well-known scientists are in universities; most of the better corporation scientists are with Bell and General Electric laboratories. Whyte claims that most companies with research facilities plan their research programs to yield immediate and measurable financial profits. Many companies mistrust scientists whose interests range beyond the immediate need of the company and these institutions attempt to make their researchers "company conscious."]

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[9] William H. Whyte, Jr., The Organization Man (Simon and Schuster, New York, 1956), 207-208, 210-211.

SECTION V

CASE STUDY: PROJECT APOLLO

A specific analysis of the manned lunar landing program (Project Apollo) has been selected as the culmination of this unit because it encompasses all of the problems we have been considering. Apollo may be viewed as a testing-ground of the relations between science and the American character in this third quarter of the twentieth century. Conclusions drawn up to this point may now be tested in examining one of the great ongoing controversies of our time.

1. To place the moon program in proper perspective, the first document details current Federal spending for all scientific activities.[1]

> Federal obligations for research, development, and R&D plant totaled $15.3 billion in fiscal year 1964, an estimated $16.5 billion in 1965, and a projected $16.1 billion in 1966. . . .
>
> Obligations for basic research rose from $1.6 billion in fiscal year 1964 to an estimated $1.8 billion in 1965 and $2.0 billion in 1966. . . . [The] share devoted to basic research rose from 11 percent in 1964 to an estimated 12 and 13 percent in 1965 and 1966, respectively. . . .
>
> Since the beginning of World War II, Federal expenditures for research, development, and R&D plant have increased from $74 million in 1940 to an estimated $15.4 billion in 1966. Over one-half (54 percent) of the cumulative Federal expenditures between 1940 and 1966 of $125 billion have been made in the last 5 years. . . .
>
> Nearly 90 percent of Federal obligations and expenditures for research and development in each of the years reported were incurred by three agencies--the Department of Defense, National Aeronautics and Space Administration, and the Atomic Energy Commission--in support of defense, space, and atomic energy programs. DOD's obligations accounted for about 50 percent of the Federal R&D total in 1964, but by 1966 they

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[1] National Science Foundation, Federal Funds for Research, Development, and Other Scientific Activities (Government Printing Office, Washington, 1965), ix-x.

> were expected to be only about 45 percent. NASA's obligations rose from 30 percent of the Federal total in 1965 to a projected 33 percent in 1966. The AEC's programs accounted for an estimated 9 percent of the Federal total during 1964-66. The remaining funds were provided by 26 other agencies which support R&D programs. . . .
>
> Approximately 70 percent of obligations for research during 1964-66 were allocated or were expected to be allocated for work in the physical sciences. An estimated 24 percent was in support of the life sciences and the remainder was distributed among the psychological, social, and other sciences.

2. Here the specific costs of the space program were analyzed.[2]

> [In its most ambitious and most expensive peacetime project the U.S. plans to send a manned flight to the moon at a projected cost of up to $20 billions. The writer, after examining other space projects, conjectures that the actual cost will exceed this early estimate. Research related to this project raises the figure to almost incalculable heights.][3]

3. In 1964 Science magazine, weekly organ of the American Association for the Advancement of Science (AAAS), polled 2,000 AAAS members about the moon program. The results indicate the views of a significant sampling of the nation's scientific community:[4]

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[2] Amitai Etzioni, The Moon-Doggle (Doubleday and Co., New York, 1964), ix-xi.

[3] The footnote outlines NASA's strategy in its attempt to gain a large federal appropriation.

[4] Science, 145 (July 24, 1964), 368. (Copyright 1964 by the American Association for the Advancement of Science.)

> [The questionnaire asks opinions about 1) the importance of a 1970 moon landing (not very important), 2) the probable date of such an achievement (ca. 1972), 3) the justification for manned moon probes (scientific), the potentiality of various fields to contribute new knowledge (biomedicine first), and 4) the percentage of the budget which should be devoted to space programs (ca. 10 to 25%). Those questioned were also asked about their education (ca. half holding Ph.D.'s) and their relationship to the space program (few directly related).]

4. The editor of Science later added a postscript:[5]

> [The writer states that some respondents added comments and he quotes one scientist who contends that the money put into the space program is easily afforded in our affluent society and that the program serves to unify the emotions of the country.]

5. Andrew T. Young, astronomer at the Harvard College Observatory, added another comment on the results of the AAAS poll:[6]

> [Young expresses surprise at some results of the poll, taking issue with the opinion that manned lunar flights could produce more knowledge than astronomy. He contends that excellent telescopes could be built on earth at a relatively low cost which would yield impressive amounts of data about truly distant space.]

6. Whatever doubts and disagreements the natural scientists may have as to the value of the moon-race, social scientists have tended to be even more skeptical. Here a Columbia University sociologist states some of the main criticisms:[7]

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[5] Philip H. Abelson, "AAAS Space Poll," _Science_, 145 (Aug. 7, 1964), 539. (Copyright 1964 by the American Association for the Advancement of Science.)

[6] _Science_, 145 (Sept. 4, 1964), 989.

[7] Amitai Etzioni, _The Moon-Doggle_, 5-8, 14-15, 197.

> [Etzioni points out that NASA's large fellowship program may cause an inordinate number of bright young men to turn to space research and leave other areas, such as medicine, poorly staffed. He argues that the nation must plan its allocation of scientists. He states that manned space flights are not essential for purposes of scientific investigation and that these flights do not enhance our prestige to the extent claimed by their champions.]

7. Perhaps the most paradoxical opinion of the moon-shot was offered by one of the nation's most respected physicists, Nobel Prize winner Harold C. Urey.[8]

> I think the Earth probably is much more interesting than the Moon. We have an atmosphere, oceans, we have erosion, we have mountains formed and washed down into the ocean, we have had life on the surface that makes fossils in the rocks, and everything of this sort, and I am expecting that if we get to the Moon that we will not find it a very interesting place to investigate, not nearly as interesting as the Earth. I think it will be rather dull, and we will find that the mountainous regions are one sort of thing and the so-called mare regions are somewhat different, and when we get through with this, that will be pretty much the end of interesting investigations.
>
> There are people that just seem to think that we want to map the entire Moon precisely in the same way that we are mapping the Earth or even in greater detail. With this I disagree. I think that there is a limited amount of interest to be gotten from the Moon, and I do not think we ought to deceive ourselves in thinking we will find an exceedingly varied object in the Moon. . . .
>
> Now some general remarks about the space program. Some of my scientific colleagues . . . argued that the space program is not worthwhile from the scientific standpoint. Well, my reply is the space program is not done for science primarily, it is done for adventure. It is adventure for me and the members of this committee, all of us here, as well as the man on the street. We have arrived at a place in the development of man where we can get to the Moon, and the whole character of man throughout history has been that when we can do a thing of this sort, somewhere someone will do it, and we will all be immensely interested in seeing that it is done. I am

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[8] U.S. Congress, House, Subcommittee of the Committee on Science and Astronautics, Hearings on 1966 NASA Authorization, 89th Cong., 1st Sess., III, 424, 426.

> interested in this from the standpoint of just seeing a man go to the Moon, and I rather think we all are. At the same time, I think it would be disgraceful if we engaged in this great adventure and at the same time did not try to learn as much on the scientific side as we possibly can, and I would say that I really think the United States is doing a much better job on the scientific side than is the U.S.S.R., and I am very much pleased that that is the case.
>
> There are arguments, too, that we could spend this money better somewhere else. Well, we could do almost anything else that we want to do in this country if we would decide to do it. The space program does not prevent us from supporting education and fighting cancer or cleaning up the country and getting rid of those terrible power poles and all sorts of things. . . .
>
> As I have remarked several times, if we discontinued the space program, the only thing I think the men that are engaged in this would probably do, would be to increase the length of the family car by a foot and make it somewhat wider, and I just hardly believe that these are very necessary things to be done at the present time. Their capacities are in that direction--not in fighting cancer or teaching country school or something of that sort. They would contribute very little in this direction.

8. One of the reasons most often advanced for pressing forward in space as fast as possible is the necessity of beating the Russians. In September 1963, in his last speech to the United Nations, President John F. Kennedy suggested another possible approach:[9]

> [Kennedy questions the necessity of racing to the moon and suggests that we explore the possibility of cooperating with others in this task.]

9. Answers to the criticisms levelled at the space program were attempted by James E. Webb, head of the National Aeronautics and Space Administration (NASA), when he testified in favor of NASA's $5 billion budget request for fiscal 1967.[10]

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[9] Time, Sept. 27, 1963, 28.

[10] U.S. Congress, House, Committee on Science and Astronautics, Hearings on 1967 NASA Authorization, 89th Cong., 2nd Sess., I, 2, 4-5, 15-16, 25-26.

Mr. Chairman, in 1961, when the Nation stood at the crossroads in its space effort, the goal of a total capability in space, to be demonstrated by manned exploration of the Moon in this decade, was selected. . . . In space we are today approaching another crossroads. Major new decisions for the future, and with implications more far-reaching than any this committee and NASA have faced together in the past, must soon be made. . . .

Last year I answered your questions as to whether we would be able to close the gap between the U.S.S.R. and ourselves by saying that we could not at the budget levels recommended. The gap is still there and this budget will not close it. We are as much as 2 years behind the Soviet Union in certain important aspects of space power. In the year just passed, 1965, they launched 52 Cosmos satellites; successfully orbited a 3-man spacecraft; demonstrated a communications satellite capability with 2 Molniya spacecraft; and orbited the heaviest payload by anyone in the world to date, indicating they have developed a new launch vehicle with some 2 1/2 to 3 million pounds of thrust. Since the beginning of 1966 they have achieved a successful soft landing on the Moon and they have reached Venus with two probes.

The Soviet program shows every evidence of a continuing major commitment to long-term, large-scale operations in space. There is little room for doubt that they are rapidly moving toward an increased frequency of manned and unmanned flights and that their capabilities will soon reach a point where they could expect success in an attempt to land men on the Moon. The massive Soviet commitment to a rapid buildup and a long-term program underlines the importance they attach to advancing their space capabilities. It will require a strong and increasing effort initiated no later than fiscal year 1968 and vigorously pushed in the years after the United States has achieved a manned lunar landing to prevent them from forging ahead as the unchallenged leader in space.

The program we began presenting to you, Mr. Chairman, in 1961, and have been elaborating in each succeeding year, was intended to meet fierce competition and to end up ahead. It was also intended to give us a number of options in space from which we could chose those offering the greatest advantages at the least cost. The competition is still fierce, and we are not yet able to feel assurance that we will end up ahead in the option areas where the Russians are developing their strongest potential.

In my view, the main question which this committee must consider as it takes up the 1967 budget is whether we can or will meet this challenge. . . .

Mr. Mosher. Mr. Chairman, don't I remember some months ago the publication of a popular opinion poll--I think it was one of the reliable polls--that listed our space program high on the list of public programs that the general public seems to think is expendable. Is this a factor . . . in the White House's apparent hesitant attitude toward NASA's program? Are they following a public opinion that is hesitant toward space too? Does public attitude concern you on our space program?

Mr. Webb. Mr. Mosher, I know of no case where the President has followed the polls when he makes decisions with respect to the buildup of these kinds of tools and the considerations of their use in the national interest for our national power position. . . . The plain fact is that we are moving into a much more difficult field, and public opinion here is less valid than the kind of analysis that we give you when you consider the total national interest.

My own view is that we must do the job and that the public will be glad it was done. I do not find, in my own personal appearances around the country, any diminution of public interest among the vigorous, forward-looking and particularly the younger people. There are, of course, also people who cannot understand why it takes so much money to operate in space.

I think it takes time to understand that we are dealing with a completely new thing when we use a rocket engine and move out from the Earth and get into situations of dynamic flight and when we build a vehicle that has the power of 6,000 Boeing 707's. The public hasn't had time to catch up with that yet. They do know there is something important here and I doubt very much that they would fail to have a reaction if they felt there was a gap in the production lines and if we, in effect, decided to abandon these fields in space to the Russians. My own view is there would be a strong public reaction against such a gap and such a decision.

Mr. Mosher. I am inclined to agree with you. . . . You are giving us your assurance, I judge, that you are not afraid of public opinion in this field but the reason for a barebones program is caused move by Vietnam than anything else? Is that an accurate statement?

Mr. Webb. Well, I think, Mr. Mosher, the longer a program like this runs and the more people there are who need $200 or $300 million for some other project and make speeches saying if we only had a few hundred million dollars that the space program is consuming, think what we could do with it in this field or that, that all of this begins to build up some question in the mind of some segments of the public. . . .

Mr. Davis. . . . Mr. Webb, a great Republican by the name of Abraham Lincoln once made the statement that public opinion was everything, that with it nothing could fail and without it nothing could succeed. I think he gained that insight after having served in the House of Representatives.

I just wanted to say this: That, of course, we have a free country and Russia has a country that is not free. It has a monolithic government, but nevertheless I would bet that Abraham Lincoln's dictum holds true in Russia and I would bet that the average Russian citizen is enormously proud of his space program and that that is the reason that the Russian leaders can get by with investing the percent of their gross national product into the space effort that they get by with investing.

Mr. Webb. Mr. Davis, this is not only important for them, but for us--that stimulation. I think you put your finger on one of the most important aspects here. They are prouder and more vigorous and ready to be dynamic than they could possibly be without this program.

Mr. Davis. I think that is exactly right and I think you are also right when you observe that it is necessary for our adrenalin tobe stimulated by the Russian effort. . . . I think if you could take a poll on the question of whether or not we ought to let Russia get ahead of us, every right-thinking American citizen--the average American citizen--would say by no means let Russia do that. Of course, nobody wants to see any waste in the space program and lots of people will say, "Why does anybody want to send a man to the Moon?" I think Dr. Teller had the best answer, by the way, to that question when somebody asked Dr. Teller before our committee--I think it was a subcommittee meeting--"Dr. Teller, what is it you expect to find when you finally get a man on the Moon?" And Dr. Teller's answer was "Russians." . . .

Mr. Ryan. In the fall of 1963, I believe, President Kennedy suggested a joint venture between the United States and Russia on a Moon program. Has there been any thinking in the past 2 years in NASA on this subject and has NASA explored this in any way?

> Mr. Webb. Mr. Ryan, we always think about any suggestion made by a President. We have, of course, looked for any evidence that they were interested and found none. In fact, I would say the evidence has all been the other way. I think you must bear in mind that any very senior national leader like the President always knows with respect to a big program like this that you wear two faces--one is cooperation and one is competition, and while you are vigorously competing and don't mean to lose to competition, you still hold out the opportunity for cooperation with the benefits that are implied there. . . .
>
> I think we are not investing any great amount of effort in trying to design spacecraft that would fly on their boosters or vice versa. They show no evidence of any kind in giving us a key, or even a partial key, that might unlock the door of cooperation.
>
> Mr. Ryan. Do you think their failure to show any evidence of interest and cooperation is due to their belief that they will succeed in arriving on the Moon ahead of us?
>
> Mr. Webb. This certainly is one element in it.

10. Since a large proportion of its staff consists of scientists, NASA has always been especially sensitive about doubts cast upon the scientific purposes of its program. Here NASA deputy chief Robert C. Seamans, Jr. defends these purposes:[11]

> Apollo is much more than a manned lunar landing effort; it encompasses an important program of scientific and technological experiments and tests, and most important, is providing a wholly new capability for a wide spectrum of space flight operations. . . .
>
> We cannot today look toward a permanent manned space station, or a lunar base, or projects for manned planetary exploration until our operational, scientific, and technological experience with major manned systems already in hand has further matured.
>
> The task before us, then, is one of definition, particularly the identification of the scientific and technological experiments and operational missions that require the presence of man in space as the observer, manipulator, and experimenter. . . .

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[11] *Ibid.*, II, 5, 6, 265-266.

> Mr. Daddario. Dr. Seamans. . . . Why did you particularly stress the presence of man? Were you including in that concept, missions to Mars of Venus where man might be involved? Or, were you not thinking of it in that concept?
>
> Dr. Seamans. I was really thinking of the whole question of the role of man in scientific investigation in space for whatever goals seem to be desirable.
>
> I think right now we cannot say exactly what man's role should be in the area of astronomical measurement. We, as you know, are going to launch the first orbiting astronomical observatory this year. This will be unmanned. We have as part of our plan for Apollo Applications a platform that would permit both solar and astronomical measurements. . . . It could have a permanent team of men who would be in orbit, resupplied, which would, of course, permit men to go up to the space station and come back down so that we wouldn't have individuals that would have to stay in space for an unlimited period.
>
> I think that we have got to continually work in flight operations with the scientific community to better define those operations areas where the man has a real role and those places where it is possible to carry out the program without man, and in those areas presumbably carry out the job at less cost. . . .
>
> I think that the time may come when we will want to have a manned expedition to the planets, particularly to Mars, just as we now have a planned expedition planned for the Moon. I think myself it is too early to decide whether that is a step that should be taken in the next 15 or 20 years, or whether that is a step that should be taken at some further distance ahead in time. I think that, as you point out, such considerations are not entirely based on whether there is a scientific justification. I think you have to look at the technological, at the operational, as well as the overall sociopolitical aspects of such a decision.

11. In 1966, for the first time, Congressional response to NASA's arguments seemed to be changing significantly. A New York Times editorial suggested some possible new bases for American policy in space exploration:[12]

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[12] The New York Times, Aug. 14, 1966, 10E.

[The account describes NASA's difficulty in getting funds from Congress. The experience of the 1960's, when the space program was enthusiastically supported, is reviewed, and it is recommended that a House committee study the space program, examine the scosts, and submit a report on the future needs and aims of the space program.]

SUGGESTIONS FOR FURTHER READING

Study of the history of American science is still so new that major works are sparse. There is as yet no conprehensive study of the subject. Probably the most useful general work is A. Hunter Dupree, *Science in the Federal Government** (Cambridge, Mass., 1957), for the period up to 1940. More recent developments are discussed in the documentary collection by J. E. Penick *et al.*, eds., *The Politics of American Science, 1939 to the Present** (Chicago, 1965). A wide-ranging collection of essays which also contains helpful bibliographies is *Science and Society in the United States** edited by Van Tassel and Hall (Homewood, Ill., 1966). *The Scientific Estate* by Don K. Price (Cambridge, Mass., 1965) is an analysis of contemporary political and social problems of science. An inside view is provided by President Kennedy's former science adviser, Jerome B. Wiesner, in *Where Science and Politics Meet* (New York 1965).

More numerous are biographical studies, notably *David Rittenhouse* by Brooke Hindle (Princeton, 1964); *Franklin and Newton* by I. B. Cohen (Philadelphia, 1956); *Asa Gray* by A. Hunter Dupree (Cambridge, Mass., 1959); *Louis Agassiz, A Life in Science* by Edward Lurie (Chicago, 1960); and the volume of biographical essays by Bernard Jaffe, *Men of Science in America* (New York, 1944).

Extremely readable and informative on many of the problems discussed in this unit is *The Scientist* by Henry Margenau, David Bergamini and the editors of LIFE (New York, 1964).

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*Available in paperback edition.